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On the Accuracy of Late Catalogues of Declination of Standard Stars. By Professor Truman Henry Safford.

If we desire to make observations with meridian instruments which shall be as accurate and independent as possible we can either refer the declinations to the zenith by direct observation of the nadir point, or by stars taken directly and by reflection, or by horizontal levelled collimators; or we can employ an instrument which turns around a vertical axis, and use it in opposite positions. In either case we shall need to determine the latitude systematically by observations above and below pole.

If this course is pursued it is best to determine the refraction coefficient also by observing stars below pole and comparatively near the horizon. With two nearly identical instruments the refraction coefficient can also be controlled by observations in the opposite hemisphere. But a great multitude of observations have been differentially interpolated in declination, as well as in right ascension, between stars absolutely determined elsewhere or at other times. At present the catalogue most used as a standard one is that of the Berlin *Jahrbuch* as compiled by Professor Auwers. The probable error of a position of this catalogue is small, although at present larger than is altogether desirable. This has led its compiler to base the zone observations now going on south of the celestial equator upon an independent determination of zero stars at the Cape of Good Hope and other favourably situated observatories; and the revision of the *Jahrbuch* list itself is now in progress.

The investigation which here follows was made in order to answer some questions which came up in a paper I am now preparing—a final revision of the declinations of 627 stars compiled for the Mexican Boundary Commission. So many new star catalogues have been published since that list was prepared in 1892 and 1893 that the probable errors of the declinations contained in it would in many cases be sensibly lessened by including them ; and these probable errors, though small enough for the practical needs of the Commission, were for some stars quite sensibly too large for convenience in the further use of the catalogue for other purposes.

The first step taken was to compare the Berlin *Jahrbuch* Catalogue with the Greenwich Ten-year and Five-year combined ; with Nyrén's Pulkova declinations for 1885 ; with the Cape Catalogue of the same epoch ; and with the Radcliffe Catalogue for 1890. The Greenwich combination includes all observations of fundamental declinations from 1877 to 1891; the Radcliffe Catalogue contains observations from 1880 to 1893 inclusive. The four modern catalogues are all dependent upon work of so nearly the same mean epoch that uncertainty of proper motion will have little effect on the comparisons, and they all cover so many 427 day periods that one principal term in the variation of latitude nearly disappears in the mean. The whole variation of latitude is eliminated from the Pulkova series by direct observations in sufficient number. This excellent catalogue is based upon double observations with a vertical circle, practically an altazimuth with a horizontal circle used only for setting. Most stars are observed with it twice in opposite positions of the face of the divided circle at the same culmination ; *Polaris* is observed four times at each culmination; but stars within five degrees of the zenith are only once observed. In this case the zenith distance changes too rapidly while the observation is going on. The probable error of an ordinary (double) observation is lessened very much by the immediate reversal, and consequent elimination, of index error ; but for the zenith stars this favourable circumstance disappears.

The normal number of double observations is eight for each star of the Pulkova Hauptsterne. Stars near the zenith are taken singly sixteen times ; but as their zenith distance below pole is about 65° at most, they are more accurately determined by sixteen single observations above pole, and eight double ones below, than the stars further south, although not quite as precisely as those further north which have eight double observations in each position.

In his paper on the variation of latitude as derived from this series, Mr. Nyrén gives the following weights for a single declination, depending on four bisections for *Polaris* (E.W.W.E. or W.E.E.W.), two for most stars E.W. or W.E., and one for zenith stars :—

	Weight.*	Probable Error.
		″
Single observations within 4° of the zenith ...	1·16	±0·38
Double observations from Z.D. 4°–50° ...	3·47	±0·22
„ „ „ 50°–65° Z.D. ...	2·31	±0·27
„ „ „ 65°–76° Z.D. ...	1·0	±0·41
Quadruple observations of Polaris	6·38	±0·16

From these probable errors and the minimum number of observations for each declination we find the probable error of the resulting mean declinations, so far as it arises from the agreement, *inter se*, of the separate observations to vary between ±0″·055 and ±0″·13 between the declinations 90° and −16°. The largest value applies to few stars, and the general average is ±0″·08. These values should be diminished for stars more frequently observed than the rule requires.

The Greenwich results for 1877 to 1891 inclusive are liable to a probable error for the single observation (according to Mr. Stone's investigation quoted in the Introduction to the Greenwich Observations) varying from ±0″·47 at the zenith to ±0″·60 at a zenith distance of 45° and ±0″·95 at 75°. The harmonic mean of the number of observations is forty-one ; and taking ±0″·55 as the average probable error of the single one, we find ±0″·09 as that part of the probable error of the mean result for fifteen years which arises from the accidental causes which are exhibited in Mr. Stone's calculations.

As is at once visible from Mr. Thackeray's tables in the *Monthly Notices* for November 1894, the combination of the two quantities ±0″·08 and ±0″·09 does not give a large enough probable error of result ; as was indeed to be expected. We do not know how the subdivisions of the degrees in Repsold's dividing engine or in the Greenwich Transit Circle were made. We shall presently see that each instrument and method of observing is apparently responsible for a residual probable error of ±0″·09, or slightly more, in the result of a large number of observations. And this estimate is for Greenwich decidedly less than the quantity ±0″·16 allowed in the Greenwich Introduction. It must, of course, be remembered that this last quantity is to be diminished before application to the final catalogue positions in consequence of the employment of many observations by reflection, and perhaps of the combination of observations above and below pole. The refraction employed was, however, not determined by bringing observations above and below pole to agree, but was Bessel's.

The Pulkova observations were reduced by a refraction coefficient derived from themselves in the manner just indicated. The number of observations below and above was very carefully regulated. The errors of division were determined for each degree,

* *Mélanges Mathématiques et Astronomiques*, vol. vii., p. 356.

and the division lines had been put on anew by the Repsolds. The residual probable error of the division lines (as at Greenwich) is probably a sensible portion of the remaining probable error of results; and such a residual error is to be determined by the combination of independent series. In these observations the variation of latitude was allowed for by direct determination.

In comparing among themselves the three catalogues, Berlin *Jahrbuch*, 1885, Nyrén 1885, and Greenwich 1877–1891, I divided them into zones of declination, and did not consider the variation in the different hours of right ascension. There were indications that this variation contained terms constant for different declinations; but on the one hand these terms were small, on the other there was no means of separating them from others of equal importance, which varied both in right ascension and declination. It seemed safe enough to allow for the variations with respect to declination directly, and leave the remainder to be included with the probable errors, which are, of course, made a little too large by them. The variations which are functions of the declination alone arise from definite causes; refraction and flexure, whose laws do not seem to be accurately known to the last degree of precision; while those variations which are functions either of the right ascension alone or of right ascension and declination conjointly include undetermined remainders from many causes, including variation of latitude. The attempt to separate the last cause from the others proved fruitless. The coefficients of the sine and cosine of the right ascension in the difference between the Berlin *Jahrbuch* and Pulkova 1885 came out so small, as compared with those of the sine and cosine of double the right ascension, that a correction formula to the *Jahrbuch* declinations, suggested by Dr. Chandler as arising from the annual term in the variation of latitude, was apparently neutralised by other causes. The course, then, of including variations depending upon right ascension in the casual errors seemed allowable so long as they were sufficiently small and irregular.

The method of dealing with the differences of two catalogues used was simply to group them in declination, and to compare each difference with the mean of its group, without smoothing them off at the boundaries of the groups by the aid of curves. In this way the casual errors are also somewhat increased by the irregularities at the boundaries. In spite of this, however, the resulting probable errors were found unexpectedly small, as will be seen when they are compared with those derived from the earlier Greenwich catalogues and the Pulkova declinations for 1865. The first group included the stars common to the *Jahrbuch* and Pulkova 1885 between 90° and 60°. It had been found by trial that a group of this extent could safely be here taken.

There were forty-nine stars; the mean $\Delta\delta$ was $-0''.08$; the

probable error of one difference by *sums* of differences was $\pm 0''\cdot196$.

This and the remaining groups in the same comparison gave the following table :—

Berlin Jahrbuch – Pulkova 1885.

Limits of Zone.		No. of Stars.	Mean $\Delta\delta$.	P.E. 1 Diff.*	Σe.
°	°		″	″	″
90	60	49	−0·08	±0·196	11·25
60	50	29	+0·01	0·216	7·28
50	40	39	−0·05	0·185	8·43
40	30	43	+0·28	0·194	9·76
30	20	46	+0·21	0·185	9·98
20	10	46	+0·23	0·174	9·23
10	0	46	+0·23	0·173	9·31
0	−10	41	+0·13	0·235	11·25
−10	−20	34	−0·31	0·267	10·57
−20	−27	7	−0·46	0·45	3·43

The original catalogue of the Berlin *Jahrbuch* and the earlier catalogue of Pulkova Hauptsterne end at −10°, and the more southerly stars were introduced into the latter partly for determination of refraction. The differences between the two series south of that limit arise in part from the two independent refraction coefficients used at Pulkova 1865 and Pulkova 1885, combined with the employment of the inside thermometer to modify the readings of the outer one.

The stars of the *Jahrbuch* south of −10° were computed (Publication xvii. of the *Astro. Gesellschaft*) from a number of other catalogues not used in the portion taken from Publication xiv. Hence the probable errors of our difference are not quite comparable in the two cases. North of −10° we have 339 stars, in eight groups, with Σe 76″·49 ; the average probable error of one difference is $\pm 0''\cdot193$. The addition of the thirty-four stars from −10° to −20° would make this value $\pm 0''\cdot200$; the remaining seven are at Pulkova below Z.D. 80°.

The next comparisons made were those between the two separate catalogues and Greenwich 1880–90; that is, the Ten- and Five-year Catalogues, combined in proportion to the number of observations : this combination I shall call Greenwich 1885 (1877·0—1892·0) ; the first group extended to 50° north declination, practically the zenith of Greenwich. The resulting table is as follows :—

* The probable errors are determined from the sums of the errors, regardless of sign, both here and in what follows.

Berlin Jahrbuch – Greenwich 1885.

Limits of Zone.	No. of Stars.	Mean $\Delta\delta$.	P.E. 1 Diff.	Σe.
° °		″	″	″
90 – 50	22	–0·06	±0·228	5·80
50 – 40	8	–0·01	0·219	1·94
40 – 30	11	+0·12	0·164	2·04
30 – 20	19	+0·16	0·155	3·39
20 – 10	27	+0·15	0·154	4·82
10 0	29	+0·17	0·207	6·97
0 – 10	24	–0·03	0·192	5·33
–10 – 20	18	–0·02	0·186	3·86

The probable error, $\pm 0''\cdot228$ in the zone 90° to 50°, is somewhat larger than that in the average of the zones south of the zenith of Greenwich, which comes out $\pm 0''\cdot181$. The reason for this difference, which seems to be real, is not a less number of observations to each star of the 22, as they are all well-known fundamentals * observed rather oftener than the average.

The comparison Greenwich 1885–Pulkova 1885 gives the following results :—

Limits of Zone.	No. of Stars.	Mean $\Delta\delta$.	P.E. 1 Diff.	Σe.
° °		″	″	″
90 – 50	22	+0·01	±0·201	5·11
50 – 40	8	–0·09	0·249	2·20
40 – 30	11	+0·20	0·157	1·95
30 20	21	+0·10	0·116	2·83
20 10	28	+0·04	0·153	4·98
10 0	29	+0·05	0·185	6·23
0 – 10	25	+0·04	0·207	6·11
–10 – 20	18	–0·36	0·181	3·75
–20 – 27	6	–0·29	0·33	2·13

We now combine the probable errors of the separate groups. Below 10° of south declination the *Jahrbuch* positions are not of approximately uniform accuracy ; and the least accurate of them are those not in the Greenwich standard list.

We can then properly divide the stars into three groups :—

A. Those between the pole and the zenith of Greenwich.

B. Those between the zenith of Greenwich and –10° of declination.

C. Those south of the last-mentioned parallel to –20° (or 80° Z.D. at Pulkova).

* I added three : *Cephei* 43 H., Groombridge 750, and *Draconis* 1 H., which Mr. Thackeray seems to have overlooked.

The probable errors in the mean are as follows :—

	B.J.-Pulk. 1885.	B.J.-G. 1885.	G. 1885-P. 1885.
Group A.	″ ±0·204 78 stars	″ ±0·228 22 stars	″ ±0·201 22 stars
Group B.	±0·190 261 „	±0·180 118 „	±0·172 122 „
Group C.	±0·267 34 „	±0·186 18 „	±0·181 18 „
General Mean	±0·200 344 „	±0·187 158 „	±0·176 162 „

The results from the general mean when properly combined indicate the probable error of Greenwich 1885, ±0″·114; of Pulkova 1885 ±0″·134; of the *Jahrbuch* declination for 1885 ±0″·148.

Professor Auwers has investigated the mean errors for the *Jahrbuch* positions by the agreement *inter se* of the materials employed.

From his data, vol. cxxxiv. col. 18 of the *Astronomische Nachrichten*, combined with the relative number of stars in the different classes, we find the average *mean* error for 1885·0 of a Hauptstern (in declination) to be ±0″·222, and of a Zusatzstern, ±0″·24. As Nyrén's stars are mostly Hauptsterne, with a few lately transferred from the other list, we can fairly take ±0″·15 as the probable error in question, agreeing very closely with the value ±0″·148. The former quantity is derived from the comparison *inter se* of the materials for the *Jahrbuch* declination, together with an estimate for the proper motions since the average epoch derived from Bradley.

We may safely conclude, then, that the probable error, B.J.—Pulkova ±0″·193 for 1885 is nearly correct. I have here omitted the last group as less accurate in both catalogues owing to the fact that the zenith distances exceed 70°.

The half of this amount, ±0″·096, can be taken as the probable error of the half sum of the declinations from the two catalogues as reduced to 1885, and including the more southerly declinations we can employ ±0″·100 as a general mean.

I now attempted a little additional test of the Greenwich declinations between the north pole and the zenith. The table of differences showed that the probable errors of the Greenwich declinations in this region were larger than elsewhere; and a plausible cause for this seemed to be the use of Bessel's refractions unchanged. The indication from several sources is that these should be slightly diminished, not by so much as was done in constructing the Nine-year Catalogue, but by a large fraction of this amount. The Greenwich declinations above and below pole are, as it seems, systematically different by a slight amount owing to this cause. Professor Auwers finds it necessary to add larger (positive) systematic corrections to the declinations below pole than to those taken above; the difference for the stars which at upper culmination pass through the zenith is about 0″·8; and the correction to the refraction coefficient is about −0″·15, which

corresponds pretty nearly to the results of Dr. Gill's investigations, and to the Pulkova tables of Gyldén.

We compare, then, the combined Greenwich declinations, 1885, with those obtained by taking the half sum of Nyrén's results for that date and those of the *Jahrbuch*. The mean of differences for the twenty-two stars north of 50° is $-0''.03$: the sum of remaining errors without regard to sign is $5''.14$, and the probable error of a difference is $\pm 0''.202$. As the probable error of $\frac{\text{B.J.} + \text{Nyrén}}{2}$ is $\pm 0''.102$ in this region, we have the p.e. of one Greenwich result

$$= \sqrt{0.304 \times 0.100} = \pm 0''.174.$$

In order to make sure of this point I examined the comparisons between results above and below pole, as given in the Introductions to the Ten- and Five-year Catalogues respectively. The number (22) of Greenwich fundamental stars between the pole and zenith seemed to me too small to furnish a base for an important conclusion. I then brought together the results given in the Introduction to the Ten-year and Twelve-year Catalogues for stars which had been observed twenty or more times each in either catalogue.

For the Ten-year Catalogue twenty-four stars within 15° of the pole gave the sum of errors $9''.16$, and probable error $\pm 0''.323$ for one difference. But there was a constant difference in this region of $-0''.15$. Allowing for this the sum of errors became $8''.46$, and the probable error $\pm 0''.304$; the harmonic mean of the number of observations was twenty-eight. In the Five-year Catalogue were found sixteen stars meeting the same condition. The sum of errors, without regard to sign, was $6''.15$, and the probable error $\pm 0''.325$, but the constant difference was more marked. All but two of the differences were negative ; the mean difference *with* regard to sign was $-0''.30$, and after it was allowed the sum of errors, without regard to sign, was $3''.91$, and the probable difference $\pm 0''.213$ for a harmonic mean of sixty-one observations.

The existence of the constant difference is plainly enough shown by the four principal polars.

	Ten-year. No. Obs.	Below–Above.*	No. Obs.	Five-year. Below–Above.*	
		"		"	* In declination; Above–Below in N.P.D.
Polaris	1433	−0·36	626	−0·46	
51 H. Cephei	595	−0·78	265	−0·48	
δ Ursæ Minoris	589	−0·69	232	−0·49	
λ Ursæ Minoris	489	−0·74	227	−0·49	
Mean ...	...	−0·64	...	−0·42	

The same phenomenon is pretty clearly visible on page 13 of the Five-year Catalogue, and less consistently on page 46 of the Ten-year.

It will probably be safe to follow the indications of the comparisons with Pulkova and the *Jahrbuch*.

So far as probable error is concerned I shall divide the stars between 90° and −10° at the zenith of Greenwich. We have then for group A, denoting by ϵ_1 the probable error of a declination in the *Jahrbuch* for 1885, by ϵ_2 of one in Pulkova 1885, and by ϵ_3 of one in Greenwich (1885) :—

$$\epsilon_1^2 + \epsilon_2^2 = (0''.204)^2 \qquad \epsilon_1 = \pm 0''.163$$
$$\epsilon_1^2 + \epsilon_3^2 = (0''.228)^2 \qquad \epsilon_2 = \pm 0''.123$$
$$\epsilon_2^2 + \epsilon_3^2 = (0''.201)^2 \qquad \epsilon_3 = \pm 0''.159$$

For group B

$$\epsilon_1^2 + \epsilon_2^2 = (0''.190)^2 \qquad \epsilon_1 = \pm 0''.139$$
$$\epsilon_1^2 + \epsilon_3^2 = (0''.180)^2 \qquad \epsilon_2 = \pm 0''.129$$
$$\epsilon_2^2 + \epsilon_3^2 = (0''.172)^2 \qquad \epsilon_3 = \pm 0''.114$$

The results from group C are abnormal, as was perhaps to be expected. The eighteen stars in it in the Greenwich Fundamental Catalogues have a larger weight in the *Jahrbuch* than the remainder of those common to the *Jahrbuch* and Pulkova, and the square of ϵ_3, the probable error for Greenwich, comes out negative. The combination of B and C gives the following results :—

$$\epsilon_1^2 + \epsilon_2^2 = (0''.199)^2 \qquad \epsilon_1 = \pm 0''.146$$
$$\epsilon_1^2 + \epsilon_3^2 = (0''.181)^2 \qquad \epsilon_2 = \pm 0''.136$$
$$\epsilon_2^2 + \epsilon_3^2 = (0''.173)^2 \qquad \epsilon_3 = \pm 0''.107$$

In order to gain a clearer idea of the increase in probable error in the Pulkova series near the south horizon I compared the Berlin *Jahrbuch* for 1885 and Nyrén 1885 with Professor Auwers's catalogue of 303 stars in *A.N.*, Nos. 2890–91, vol. cxxi. Below −15° I did not attempt the triple comparison. But from +6° the northern limit of the 303 stars to −15° I found the following equations, in which ϵ_4 denotes the probable error of a declination from the 303 stars :—

$$\epsilon_1^2 + \epsilon_2^2 = (0''.220)^2 \qquad \epsilon_1 = \pm 0''.160$$
$$\epsilon_1^2 + \epsilon_4^2 = (0''.199)^2 \qquad \epsilon_2 = \pm 0''.150$$
$$\epsilon_2^2 + \epsilon_4^2 = (0''.191)^2 \qquad \epsilon_4 = \pm 0''.118$$

The catalogue of 303 stars is obtained by a combination of observations at the Cape of Good Hope, Madison, Annapolis, and Cordoba ; for some cases (none of which are included in these

comparisons) a few other observations are added. The Cape results combined with the Cordoba Catalogue would lead us to expect a probable error of rather less than $\pm 0''\cdot16$; so that if the weight of the Madison and Annapolis observations is about equal to that of the Cape and Cordoba the probable error of all would be approximately $\pm 0''\cdot11$, and the mean epoch very little different from 1885.

The value of $\epsilon_1^2+\epsilon_2^2=(0''\cdot220)^2$ is larger than was found for group B as a whole by the previous comparisons, but not more than the average declination would lead us to expect. In order to extend the value still farther south I compared Nyrén (Pulkova 1885) with $\frac{1}{2}$ (B.J.+303) and found in the mean

$$\epsilon_2(+6^\circ \text{ to } -15^\circ) = \pm 0''\cdot158$$
$$\epsilon_2(-15 \text{ to } -26) = \pm 0\cdot265$$

considering the probable error of $\frac{1}{2}$ (B.J.+303) $\pm 0''\cdot100$ to apply to the southern limit of the Pulkova list.

The next set of comparisons made were those of the declinations of the Cape Catalogue for 1885 with the half sum of B.J.+Nyrén. The results were divided into two groups, according as the number of observations at the Cape was ten or more, or less than ten. No comparison was made north of $+40^\circ$ or south of -20°. The groups are from 10° to 10°, and the harmonic mean number of observations is given for each group.

Comparison of Cape Catalogue with $\frac{1}{2}$ (B.J.+Nyrén).

Declination.	Harmonic Mean No. Obs.	Mean Δδ.	No. Stars.	P.E. 1 Diff.	Harmonic Mean No. Obs.	Mean Δδ.	No. Stars.	P.E. 1 Diff.
$+40^\circ$ to $+30^\circ$	15·5	$-0''04$	13	$\pm 0''257$	2·8	$-0''10$	17	$\pm 0''556$
$+30$ to $+20$	15·5	$+0\cdot06$	14	$\pm 0\cdot273$	3·8	$-0\cdot01$	26	$\pm 0\cdot329$
$+20$ to $+10$	16·7	$+0\cdot11$	24	$\pm 0\cdot290$	2·5	$-0\cdot08$	20	$\pm 0\cdot319$
$+10$ to 0	23·8	$+0\cdot24$	42	$\pm 0\cdot157$	4·2	$+0\cdot44$	4	$\pm 0\cdot290$
0 to -10	20·5	$+0\cdot25$	41	$\pm 0\cdot138$	...	...	...	...
-10 to -20	19·6	$+0\cdot28$	33	$\pm 0\cdot198$	...	...	...	...
General Mean	19·4	...	167	$\pm 0\cdot197$	3·1	...	67	$\pm 0\cdot385$

The probable error of $\frac{1}{2}$ (B.J.+Nyrén) being taken as $\pm 0''\cdot100$ we have

P.E. Cape	19·4	observations	$\pm 0''170$
	3·1	„	$\pm 0\cdot372$

Between $+10^\circ$ and -20° we find the probable error of about twenty Cape observations to be

$$\sqrt{(0\cdot184)^2-(0\cdot100)^2} = \sqrt{0\cdot284\times0\cdot084} = \pm 0''\cdot154.$$

A similar comparison was made with the Radcliffe Catalogue for 1890. As this depends upon the observations from 1880 to 1893 inclusive its mean epoch is not essentially different from that of the other catalogues compared.

The stars were grouped as for the Cape Catalogue, namely, those observed more than ten or more times in a group (α) and those observed less than ten times in a group (β). As the separate groups often contained few stars, I took the mean $\Delta\delta$ for each zone, giving half-weight to a star in group (β) and weight-unity to one in group (α).

Limits of Zone.	Mean $\Delta\delta$.	Probable Diff. 1 Star (α).	No. Stars (α).	Probable Diff. 1 Star (β).	No. Stars (β).
° °	″	″		″	
90 −80	−0·02	±0·184	5	...	(1)
80 70	−0·06	0·105	9	±0·211	9
70 60	−0·47	0·162	12	0·373	6
60 50	−0·61	...	(1)	0·343	14
50 40	−0·42	0·217	3	0·361	16
40 30	−0·57	0·244	11	0·258	14
30 20	−0·86	0·208	13	0·266	16
20 10	−0·92	0·199	16	0·267	25
10 0	−0·90	0·210	5	0·308	26
0 −10	−0·78	0·210	13	0·385	30
−10 −20	−0·62	0·233	12	0·336	21
−20 −30	−1·23	0·27	4	0·38	2
General Mean	...	±0·201	103	±0·316	179

Allowing ±0″·100 for the probable error of $\frac{\text{B.J.}+\text{Nyrén}}{2}$ we find

P.E. 1 declination R.C., 10 observations or more ±0″·174
less than 10 observations ±0·300

For the first division the harmonic mean of the number of observations is 15·1 ; for the second, 4·3.

In order to get an estimate of the probable error of the Greenwich declinations for a less number of observations I had already compared 200 stars from my Mexican Boundary calculations. The probable error for two, three, or four observations was found ±0″·346. This applies to the Ten-year Catalogue and to the stars since observed, of which I had collected the observations from the annual volumes of results ; and the quantity found is very nearly equal to Professor Auwers's result for his weight unity for the Nine-year Catalogue. As an intermediate step I compared the mean of B.J. and Nyrén with the Five-year or Ten-year, so far as the latter's numbers are given

in the Five-year, taking as the Greenwich declination to be used the one of the two in which the observations are less in number. This gave me for a harmonic mean of nine observations $\pm 0''.193$ as the probable error of a Greenwich declination.

We can now place side by side the probable errors of the results of the three English instruments.

	G.		C.		R.
	"		"		"
3	±0.346	3.1	±0.372	4.3	±0.300
9	±0.193	19.4	±0.170	15.1	±0.174
41	±0.114	...	...	...	...

The accidental error of a single observation at either place at not too great a zenith distance is not very far from $\pm 0''.50$ on the average. By a simple calculation it will be seen that the probable errors in the little table include some additional source of uncertainty, which is common to all the observations of the same star at the same place. For the forty-one Greenwich observations this appears to amount to $\pm 0''.08$; for the 19·4 Cape observations to $\pm 0''.13$, for the 15·1 Radcliffe observations to $\pm 0''.12$. The Cape Catalogue is based upon only six years' observations, and the variation of latitude is perhaps less perfectly eliminated in the individual stars.

The assumption of a comparatively large constant error which cannot be diminished by repeated observation is one which is frequently made. Argelander (*Bonn Observations*, vol. vii. p. 45) assumes that such a constant error is not less than that arising from four single observations, which would give $\pm 0''.25$ in place of the quantities varying from $\pm 0''.08$ to $\pm 0''.13$, which we have just obtained. For Pulkova we find

$$\sqrt{(0''.134)^2-(0''.080)^2}=\sqrt{0''.214\,.\,0''.054}=\pm 0''.11.$$

Professor Boss employs (in his memoir on standard declinations) for various catalogues a ratio of casual to constant error, $\frac{\epsilon}{\epsilon_1}$, equal to either 2, 3, or 4. For the two Seven-year Catalogues, and those later observations which he used, he adopts $\frac{\epsilon}{\epsilon_1}=3$, which makes the constant error for the Greenwich declinations $\pm 0''.17$; while for Mr. Main's results with the Carrington circle he takes $\frac{\epsilon}{\epsilon_1}=2$, and the constant error in any one year would be more than $\pm 0''.25$ for these observations, as the instrument was differently handled before 1880.

It is plain to be seen that the two instruments do not inevitably bring about such large constant errors. We may safely assume that after the variation of latitude has been completely eliminated the remaining discrepancies are due to three

causes rather than two. We have in the first place ordinary casual error arising from variation in bisection of the star or the divisions, or in refraction ; in the third place, the unrecognised remainders of division error. Between the two we have a cause which depends upon the combination of the circumstances which enter into the observation by a given astronomer with a given instrument. This is likely to vary in its effects with the same observer from year to year, and with the same instrument used by different observers. That is to say, if the fundamental stars observed at Greenwich had been each observed forty times and no more during the years 1878 and 1891 inclusive, and if each one had been taken by ten different astronomers in groups of four observations each, there would no doubt be indications that ten different constant errors would be joined to the casual error on the one hand, and to the instrumental constant error on the other ; so that the resulting probable error would be somewhat less than it is found by the previous investigation. The pure casual error would be less when the personalities are eliminated ; the regularity of distribution would slightly diminish the effect of the personalities on the result.

It may be worth while to add a comparison of these with the previous results relating to the accuracy of the declinations of the best catalogues. Professor Auwers adopts the following formula for the mean error of a declination of his Bradley catalogue for a star observed n times :—

$$\epsilon = \sqrt{0\cdot35 + \frac{1\cdot36 + 0\cdot085 \tan^2 z}{n}}.$$

For a zenith star observed twenty-five times with the brass quadrant this would give a mean error of $\pm 0\cdot64$, or probable error $\pm 0''\cdot43$; for one observed four times a mean error of $\pm 0''\cdot83$, or probable error $\pm 0''\cdot56$. The quantity $0\cdot35$, which is nearly equal to one-fourth the square of casual error of an observation, is the result of a rough estimate, and these numbers are quite as likely to be too large as too small.

Argelander's Åbo catalogue seems to be more accurate than his own estimate would make it. His own expressions for the probable casual error of a single observation are

$$0^s\cdot0312 + 0^s\cdot0210 \sec \delta \text{ in A.R.}$$

$$0''\cdot859 + 0''\cdot0644 \tan z + 0''\cdot02577 \tan^2 z \text{ in Dec.}$$

Here z is the zenith distance.

He estimates the probable constant error arising from error of division as $\pm 0''\cdot208$.

The formulæ are given in his paper on the solar motion, in the *Mém. des Savants Etrangers* of the Petersburg Academy of Sciences for 1837, and have been rarely noticed.

The usual number of observations for which Argelander calculates the probable error is eight, at a zenith distance of 50°.

For the fundamental and circumpolar stars, assuming the harmonic mean of the number of observations to be fifty, we should

get $\pm 0''.25$ approximately. Professor Boss' weights for eight and fifty observations are respectively 2·0 and 3·5, to which correspond probable errors of $\pm 0''.21$ and $\pm 0''.16$; the probable error of the unit of weight is $\pm 0''.3$ in his investigations. It is probable that Argelander estimates the constant error $\pm 0''.208$ on too liberal a scale, and that the zenith distance of 50° is too large for the average of the stars which are not circumpolar. If we adopt the average casual probable error of one observation as $\pm 0''.91$ we should get for its effect $\pm 0''.35$ for eight observations and $\pm 0''.13$ for fifty, leaving still unexplained differences.

The probable difference of declination between a star in the Åbo Catalogue and in Struve's *Positions Mediæ* is $\pm 0''.39$. Struve's normal number of observations is six, with a less probable error to the single observation—about $\pm 0''.6$ on the average. With the assumption of $\pm 0''.208$ for the error of division of the Åbo circle, and a similar assumption of $\pm 0''.1$ for the Dorpat instrument, we should have $\pm 0''.28$ for the probable difference Åbo-Dorpat for a fundamental star, and $\pm 0''.44$ for a non-fundamental. The ordinary assumption that the probable errors of the Dorpat and Åbo Catalogues are on the average equal is rendered plausible by the results of various comparisons made by Auwers, Seyboth, and others. Boss adopts the same weight for the two authorities, which does Struve a slight injustice, so far as his own personal observations are concerned. After he gave the circle over to his assistants it became, in all probability, more difficult to read the verniers.

The following little table contains the probable errors derived from Boss' formulæ for a mean of three observations, and of forty, from the better catalogues between 1830 and 1880:—

	3 Obs.		40 Obs.	
	Wt.	P.E.	Wt.	P.E.
		″		″
Åbo, 1830	1·0	±0·30	3·5	±0·16
Dorpat, 1830	1·0	0·30	3.5	0·16
Airy, Cambridge	0·5	0·42	1·5	0·24
Edinburgh, 1837	0·7	0·36	1·5	0·24
Greenwich, 1840	0·5	0·42	2·0	0·21
Radcliffe, 1845	0·3	0·55	0·7	0·36
Armagh	0·2	0·67	0·4	0·47
Jacob, 1850	0·3	0·55	...	...
Greenwich, 1845	0·6	0·39	2·5	0·19
Greenwich, 1850	0·5	0·42	2·0	0·21
Paris (Laugier)	0·7	0·36	2·5	0·19
Greenwich, 1860	1·0	0·30	3·0	0·17
Paris, 1860	1·5	0·24	3·5	0·16
Brussels, 1860	0·6	0·39	2·0	0·21
Greenwich, 1864	1·0	0·30	3·0	0·17
Brussels, 1865	1·0	0·30	4·0	0·15
Melbourne, 1868	1·0	0·30	2·0	0·21
Greenwich, 1870	0·7	±0·36	2·0	±0·21

For the following catalogues little or no difference exists between the accuracy of the individual declinations, usually because the ordinary number of observations varies but little ; in one or two of the less accurate catalogues because it is difficult to separate casual and constant error :—

Authority.	Usual No. Obs.	Boss' Weight.	Probable Error.	
Piazzi, 1800	...	0·1	″ ±0·95*	* I ordinarily adopt ±0″·8 for the probable error of a declination from Piazzi.
Groombridge, 1810	6	0·3	±0·57	
Pond (Olufsen), 1822	...	1·0	±0·30	
Cape (Henderson)	...	1·0	±0·30	
Königsberg, 1838	...	0·6	±0·39	
Königsberg, 1843	40	1·5	±0·24	
Bonn, 1866	8	1·0	±0·30	
Leyden, 1866	...	5·0	±0·13	
Leipzig, 1867	...	1·0	±0·30	

Boss' discussion of the Pulkova declinations of 1845 refers to the first, less correct, edition ; later the errors of division were more minutely allowed for, after the discovery of the scale by which Ertel subdivided the degrees on the vertical circle.

In some cases Professor Boss assigns weights (depending on more than forty observations) which equal that given to circumpolar or fundamental stars at Leyden. His maximum is 5·0, but is very rarely applied. We may safely consider that in no case is 5·0 on his scale exceeded during the period contained in his researches.

Professor Auwers has investigated the accuracy of the declinations of the Hauptsterne combined in the *Jahrbuch* Catalogue. The results are in part as follows, reduced from mean to probable error :—

Catalogue.	Date.	Max. Weight.	Probable Error. Max. Weight.	Probable Error. Unit Weight.
Pulkova	1845	4	″ ±0·15	″ ±0·29
	1865	7	±0·16	
Greenwich	1861	3	±0·21	0·37
	1872	4	±0·18	0·35
Leyden	...	5	±0·19	0·42

The weight assigned to Pulkova 1865 is relatively high ; the number of observations is frequently but four (double), and the invariable weight, 7, was assigned without knowledge of this

number. For the Leyden stars weight 5 was given to sixteen or more single observations.

We can now obtain an approximate idea of the general improvement of the accuracy of observations of declination during this century.

The catalogue of Piazzi is evidently less accurate than Auwers's *Bradley*, and requires re-reduction, as has long been known. Groombridge's declinations, usually depending on six observations, are affected with a probable error of $\pm 0''.57$ according to Boss, of $\pm 0''.53$ according to Auwers (see his paper in vol. lxiv. of the *Astronomische Nachrichten* many years ago). The Reichenbach circles, read by verniers, used by Bessel, Argelander, Struve, and others, leave a residual probable error of $\pm 0''.2$ (or perhaps less) depending on errors of division. The subdivision of the degrees on the circles may possibly have been effected by the same process as that of the Pulkova vertical circle, the work of Reichenbach's successor, Ertel. Errors of division of the same order are indicated by Professor Valentiner in his observations made at Karlsruhe with a reconstructed circle divided by Reichenbach. As the older Reichenbach circles were read by verniers it is difficult to trace the effects of division errors in the different minutes of the same degree. Argelander's estimate of $\pm 0''.208$ for the ultimate probable error of his results seems to be too large.

The English and French mural circles seem to have been excellently divided, at least for the time: this is shown by Professor Boss' estimates for the probable error of forty observations; for these instruments it is about $\pm 0''.20$.* The circles were at least occasionally moved into different positions with respect to the telescopes, and six microscopes were usually employed for the standard observations. The two circles used at Armagh and at Oxford up to about 1862 were less accurate. They are mounted as meridian circles, and divided on their faces.

The newer English transit circles, according to Boss' investigations, gave about the same probable error for forty observations; $\pm 0''.19$, including the two Greenwich Catalogues for 1860 and 1864, and the results which he has combined for 1870. Nearly the same value is obtainable from Professor Auwers's investigations. The Pulkova vertical circle was investigated by Boss from the older results for 1845, by Auwers from the newer.

The minimum probable error for this series, according to Boss, is, however, $\pm 0''.13$, according to Auwers $\pm 0''.15$; the variation is in the wrong direction. To explain this we have to note that probably the stars employed by Boss were those which had been most frequently observed; they were, at any rate, a selection from the Hauptsterne, while Auwers's catalogue and the *Jahrbuch* contain them all, with but few

* This does not include the inferior instruments used at Madras and the Cape before 1839.

exceptions. Boss' estimate of probable error is not strictly derived from his own investigation, but is confirmed by it.

For the Pulkova Catalogue of 1865 a minimum of four observations was considered sufficient. The probable casual error thence arising may be estimated in the mean at about ±0″·14 with a sensible decrease either for the stars observed below pole also, or more frequently observed above.

We can now make a comparison between the accuracy of the Greenwich results obtained from the mean of the two Seven-year Catalogues, as combined by Professor Auwers, and the combination of the Ten- and Five-year Catalogues. The probable error of weight 3 (more than fifteen observations in the two Seven-year Catalogues) is ±0″·165, according to my calculation. Auwers gives as *mean* error for weight 3 ±0″·318, which would give ±0″·214 for probable error. The difference is due to the fact that the latter value does not allow enough range in the scale of weights for Greenwich 1861. See *A.N.*, vol. cxiv. col. 14, where Professor Auwers makes a similar remark. The value ±0″·165 is now reduced at Greenwich to ±0″·114 for the general average of the zones not too far south.

We may for the moment adopt the hypothesis of a constant error to each star arising from uncorrected errors of division. The harmonic mean number of observations is approximately forty, and the average probable error of the mean not far from ±0″·09. Consequently

$$\pm 0''{\cdot}14 = \sqrt{(0{\cdot}165)^2 - (0{\cdot}09)^2}$$

must be allowed for constant error on this hypothesis. The corresponding number for 1877–91 is

$$\pm 0''{\cdot}06 = \sqrt{(0{\cdot}114)^2 - (0{\cdot}09)^2},$$

but this is rather uncertain. At any rate, the value ±0″·09 is an extreme limit of possible constant error for the fifteen years. The hypothesis is not entirely confirmed. It is safer, however, in determining a scale of weights to proceed cautiously in adopting any hypothesis as to the make-up of the probable errors, and obtain as nearly as possible empirical values of the probable error for different numbers of observations. The thing to be avoided is not so much apparent inequalities of slight amount in contemporaneous series which contain the same stars, as large errors in assigning relative weights to old work compared to new. Astronomers frequently make the mistake of overestimating the weight of a series which has been long known and used. The probable error of the declination of a Hauptstern from the *Jahrbuch* is now on the average ±0″·28, and for 1900 ±0″·31; while if the same star's declination has been largely observed about 1885 at the four observatories of Pulkova, Greenwich, the Cape, and Oxford (the Radcliffe), the probable error would be for 1885 but ±0″·07, for 1895 ±0″·09, for 1900

$\pm 0''.11$. A star observed at Pulkova and Greenwich only would have a similar probable error for 1885 of $\pm 0''.09$, for 1895 $\pm 0''.10$, for 1900 $\pm 0''.12$; and the catalogue (Pulkova) which contains most fundamental stars would give alone for 1885 $\pm 0''.13$, for 1895 $\pm 0''.14$, for 1900 $\pm 0''.15$.

It is pretty clear that before using the *Jahrbuch* Catalogue definitely for any important purpose it will be well to wait for the completion of the revision now in progress. The general considerations just brought forward have another application, viz., to the arrangement of future observations.

Bringing together, then, in tabular form the results for the probable errors of the stars in various catalogues which have been observed the number of times adopted for standard declinations we have

Catalogue.	No. Obs. Harm. Mean.	Probable Error of Dec.	Internal P.E.	Constant Error.
Greenwich, 1861 †	40	$\pm 0''.165$	$\pm 0''.09$	$\pm 0''.14$
Greenwich, 1872	38	$\pm 0''.163$	$\pm 0''.09$	$\pm 0''.13$
Greenwich, 1885 ‡	41	$\pm 0''.114$	$\pm 0''.08$	$\pm 0''.08$
Pulkova, 1865	4 or more ‖	$\pm 0''.159$	$\pm 0''.11$	$\pm 0''.11$
Pulkova, 1885	12 ‖	$\pm 0''.131$	$\pm 0''.08$	$\pm 0''.10$
Leyden, 1868	16 ¶	$\pm 0''.188$	$\pm 0''.12$	$\pm 0''.14$
Cape, 1885	19	$\pm 0''.169$	$\pm 0''.12$	$\pm 0''.12$
Oxford, 1885	15	$\pm 0''.170$	$\pm 0''.13$	$\pm 0''.11$
Greenwich, 1880 or 1890 §	9	$\pm 0''.193$	$\pm 0''.18$	$\pm 0''.07$

The "Internal P.E." is a rough estimate of the effect on the mean of the casual errors of the individual observations, and the quantities in the last column are very rough when derived, as in the last line, from the difference of squares of two nearly equal values. The quantities in the column of "Probable Error" are derived from Professor Auwers's researches for Pulkova 1865 and Leyden 1868; for the catalogues Greenwich 1861 and Greenwich 1872 they are taken from the residuals for weights 3 and 4 respectively in Publication 14 of the *Astronomische Gesellschaft*, with due allowances. Professor Auwers remarks in the article that the increase of precision with the number of observations is greater than had been supposed; which rendered it desirable to investigate these numbers independently rather than to give his probable error for weight 1 reduced by dividing by $\sqrt{3}$ and $\sqrt{4}$. This would have given $\pm 0''.21$ and $\pm 0''.18$ respectively.

It was with great regret that I gave up the idea of including

† Combined by Professor Auwers. ‡ 1880 and 1890 combined. § The catalogue which had less observations. ‖ Double observations. I have not the actual numbers. The number 12 is a rough approximation. ¶ Something must be added to this number for the circumpolar stars.

the observations made at Madison, Wisconsin, between 1887 and 1892. They are evidently excellent, but exhibit a periodicity in right ascension which far exceeds that shown in the other series. And one reason for this is plain : they do not include a sufficient number of 427-day periods of the latitude variations. The investigation of the detailed corrections necessary to eliminate the total variation of latitude would be too serious a matter for me to undertake for my present purpose ; and it would seem unjust to the excellent series to apply empirical corrections. The numbers contained on pages 35 and 36 (publications of the Washburn Observatory 8) are not yet tabulated ; if we should apply a rough interpolation from them, as I have inadvertently done in a few cases where I needed the results, we should make a mistake, because the mean difference of all the declinations is contained in both tables, and would thus be applied twice. One of the tables should have been first formed, its results subtracted from the individual differences, and the second table formed from the remainders ; and another approximation to the first table might then be made if need be. Usually the $\Delta\delta_\delta$ are the more important, and should be first obtained ; then the $\Delta\delta_\alpha$ and the revised values of the $\Delta\delta_\delta$. Whether the systematic corrections to the declinations are actually of the form of $f(\delta) + \psi(\alpha)$ is of course doubtful ; and some astronomers seem to me to carry this form too far, especially when the observations so corrected are purely differential. In such cases one may suspect that agreement has been attained at the expense of truth. In this investigation I have pursued an extreme course in the other direction ; have employed $\Delta\delta_\delta$, not from a curve, but from discontinuous averages ; and have omitted $\Delta\delta_\alpha$ altogether. The result has been that my computed probable errors are rather too large ; and the decided improvement visible in them since 1880 is certainly not overstated. I should be far from asserting that a constant error of $\pm 0''{\cdot}10$ is inherent in Nyrén's admirable series. The average constant error of the catalogues here investigated, whose epochs are about 1885, is $\pm 0''{\cdot}10$, and this seems to express a trustworthy result, as the smaller of the two values used to obtain it is substantially based upon the intercomparison of Greenwich and Pulkova : if the probable error of one is increased that of the other side will be diminished. The residual error of division for the Lund circle divided by the Repsolds, and in this similar to the Pulkova instrument in its present state, is $\pm 0''{\cdot}065$ for four microscopes, or $\pm 0''{\cdot}046$ for eight. At Greenwich $\pm 0''{\cdot}16$ is allowed for this and other causes in weighting circumpolars ; evidently too much. The probable error of six degree lines at Greenwich is about $\pm 0''{\cdot}03$. The batches of six lines separately determined for polar stars and the nadir indicate a probable error of about $\pm 0''{\cdot}04$ for the individual batch by comparing each with its neighbours. The other subdivisions of degrees have not been determined at Greenwich, and it is not easy to guess whether they would on the average

exhibit larger errors—possibly enough to fill the gap between $\pm 0''.04$ and $\pm 0''.08$.

The errors of division of the Leyden circle were determined for every line. The constant error of $\pm 0''.14$ indicated by Professor Auwers's researches must therefore be accounted for either by the casual errors of this determination, or by the variations of latitude during the comparatively short period included in the time of observation, or by unknown causes.

There seems to be no doubt, I may say in conclusion, that the accuracy of fundamental declinations has substantially gained during the past half-century, as well as during the century which preceded; and that the errors resulting from faulty divisions and serious flexures are now far less harmful than they formerly were.

Williamstown, Mass, U.S.A.:
1895 *May* 31.

Comparison of the Sun's Longitudes for 1900 *computed from Newcomb's Tables of the Sun with those computed from Le Verrier's Tables.* By A. M. W. Downing, M.A., D.Sc.

In view of the probability of the adoption of Professor Newcomb's Tables of the Sun in some, at all events, of the astronomical ephemerides at an early date, the publication of the following comparison may be of interest. It exhibits the corrections to apparent longitudes of the Sun, taken from Le Verrier's *Tables du Soleil*, deduced from the corresponding longitudes taken from Professor Newcomb's tables, at eight-day intervals during the year 1900. The materials for computing the latter longitudes have been communicated to me by Professor Newcomb, in advance of the publication of his tables, accompanied by his courteous permission to publish the results if I thought fit to do so.

The mean of the forty-six individual corrections for the year is $-0''.485$. It should be pointed out, however, that the value of the constant of aberration adopted by Professor Newcomb is $20''.50$, whilst that adopted in Le Verrier's tables in $20''.45$. If the same value of the constant be adopted in both tables the mean correction to Le Verrier becomes $-0''.435$.

Longitudes of Sun 1900.

Corrections to Le Verrier's Tables.

Day.	Correction.	Day.	Correction.	Day.	Correction.
	″		″		″
Jan. 1	−0·43	May 9	−0·04	Sept. 6	−0·84
9	−0·50	17	+0·12	14	−0·87
17	−0·32	25	+0·09	22	−0·93
25	−0·19	June 2	−0·07	30	−1·08
Feb. 2	−0·27	10	−0·07	Oct. 8	−0·97
10	−0·22	18	−0·04	16	−0·93
18	−0·07	26	−0·16	24	−1·17
26	+0·02	July 4	−0·43	Nov. 1	−1·24
Mar. 6	−0·10	12	−0·42	9	−1·09
14	−0·07	20	−0·35	17	−1·13
22	+0·12	28	−0·56	25	−1·25
30	+0·01	Aug. 5	−0·75	Dec. 3	−1·10
Apr. 7	−0·01	13	−0·70	11	−0·93
15	+0·06	21	−0·70	19	−0·95
23	+0·01	29	−0·82	27	−0·97
May 1	+0·01				

Nautical Almanac Office:
1895 *September* 9.

Description of a Mechanical Apparatus for computing Refractions.

By W. E. Cooke.

(*Communicated by Sir Charles Todd.*)

This consists essentially of two scales, B and F, sliding in parallel grooves, a movable pointer, P (shaded in the diagram), and two fixed scales for barometer and thermometer respectively.

A, C, E, G are narrow strips of metal serving as guides to the movable portions.

B is a strip of brass, 21 in. × 3 in. × $\frac{3}{16}$, on which are ruled divisions as follows: 17 longitudinal lines divide it into 18 rows, the fourth line from the top being rather thicker than the others. In making the short vertical graduations two different scales were used, one inch representing ·0200 for the first four rows, and three inches representing the same quantity for the remaining 14. The commencement of each row represents successively the logs. 0·3200, 0·6200, 0·9200, 1·2200, 1·4700, 1·5200, 1·5700, &c., to 2·1200, and the figures inscribed are the antilogs corresponding to the scale numbers thus obtained. (It will be noticed that the antilogs overlap, *i.e.* the figures at the end of

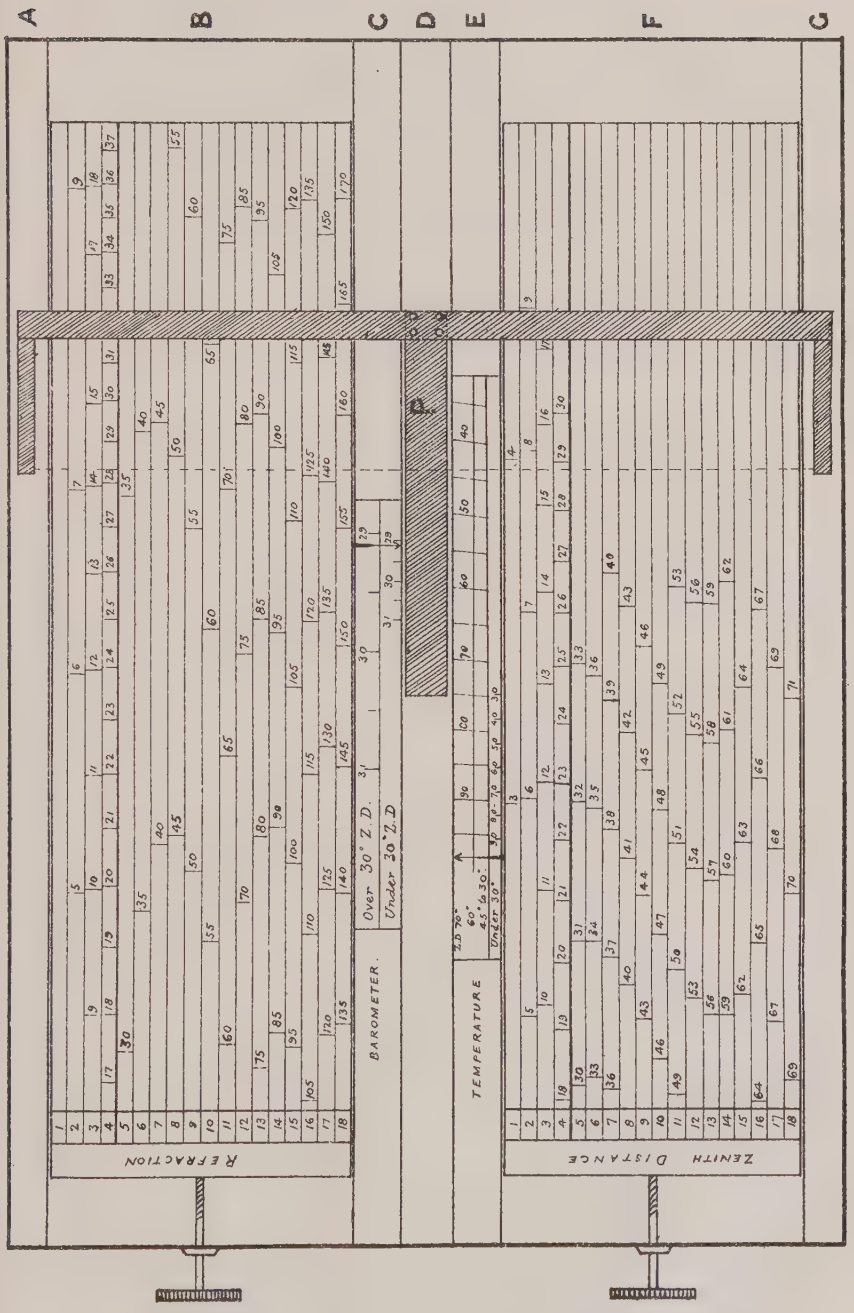
each row are repeated at the commencement of the next; the amount of this overlap corresponds to at least ·0720.)

F is of the same width and thickness, but need not necessarily be quite as long as B, for very little overlap is required. The same scales as before are used. The commencement of each row represents successively 0·3000, 0·6000, 0·9000, 1·2000, 1·4500, 1·5000, 1·5500, &c., up to 2·1000, and the figures inscribed are the Z.D.s which correspond to the various logs according to the refraction tables published as an appendix to the Greenwich Observations of 1836. These extend from 3° to 71° Z.D.

B and F are each provided with a fine pointer which extends at right angles across the strips C and E respectively. These pointers may be affixed to any part of the edge. The movable (shaded) pointer, P, consists of a fine black thread stretched at right angles to B and F on a frame which slides in the groove D. The arm of this pointer is for convenience graduated from 1 to 18 to correspond with the rows in B and F. The barometer scale on C is laid down as follows. A point is arbitrarily selected, and the scale, with the graduations increasing to the left, is placed so that this arbitrary point reads 0·0200. The barometer readings corresponding to the various logs. as given in Table I. of the "Appendix" are then plotted, each scale being, of course, employed in turn. For the temperature curve a little more care is required, for it becomes necessary to employ Tables II. and IV. To obtain the zero point, B and F are moved until the pointer of B is on ·0200 of the barometric scale and the initial lines on B and F are collinear (as indicated by the movable thread); the pointer of F will now indicate the zero point for temperature. The small scale (giving Z.D.s 0° to 30°) can be used in a similar manner to that just indicated for the barometer, but the logs must increase to the left, and the zero point will correspond to ·0000. With the large scale the temperatures can also be put down from Table II., and these will be the correct readings for Z.D.s up to 45°. In order to obtain the top line (Z.D. 70°) we must add together the figures for 70° Z.D. in Table IV. and those in Table II. We now connect corresponding points by short straight lines, and intermediate longitudinal lines can be drawn to represent the various Z.D.s between 45° to 70°. (I am afraid that in the diagram the line for 60° Z.D. is not very accurately laid down.)

To use the apparatus.—Move B, by means of the slow-motion screw, until the pointer stands opposite the correct barometer reading; move F to the proper temperature reading, and move the thread to the proper reading of Z.D., as shown in one or other of the rows on F. The thread reading on the corresponding row of B will be the refraction required.

It will be found that if this apparatus be carefully graduated on the scale indicated, refractions can be obtained with certainty to the nearest tenth of a second of arc, and with a little care the error will never exceed two or three hundredths.



APPARATUS FOR COMPUTING REFRACTIONS.

PROFT SWOSE & CO LTD LONDON

Observations of Phenomena of Jupiter's Satellites with the 8-inch Equatorial at Windsor, New South Wales, in the year 1895.
By John Tebbutt.

Day of Obs.	Satellite.	Phenomenon.	Phase.	Mag. Power.	G.M.T. of Observation.	Mean Time of *N. Almanac.*
					h m s	h m s
Feb. 4	III.	Ecl. R.	First seen	74	23 50 20	23 52 42
4	III.	,,	Full brightness	,,	23 57 8	
8	I.	,,	First seen	,,	0 13 44	0 14 17
8	I.	,,	Full brightness	,,	0 17 40	
11	III.	Occ. R.	First seen	132	23 23 15	
11	III.	,,	Bisection	,,	23 24 25	23 30
11	III.	,,	Last contact	,,	23 26 6	
12	III.	Ecl. D.	Began to fade	74	0 57 27	
12	III.	,,	Last seen	,,	1 5 35	1 3 59
14	I.	Occ. D.	First contact	168	22 44 14	
14	I.	,,	Bisection	,,	22 46 44	22 48
14	I.	,,	Last seen	,,	22 48 39	
15	II.	Ecl. R.	First seen	74	21 44 8	21 45 25
15	II.	,,	Full brightness	,,	21 46 51	
15	I.	Tr. Egr.	Int. contact	,,	22 15 41	
15	I.	,,	Bisection	,,	22 17 36	22 20
15	I.	,,	Ext. contact	,,	22 20 35	
22	I.	Tr. Ingr.	Ext. contact	200	21 54 41	
22	I.	,,	Bisection	,,	21 56 58	21 54
23	I.	Ecl. R.	First seen	74	22 34 1	22 34 28
23	I.	,,	Full brightness	,,	22 37 26	
Mar. 1	III.	Tr. Egr.	Bisection	,,	20 58 38	21 0
1	III.	,,	Ext. contact	,,	21 5 22	
1	II.	Occ. D.	First contact	132	21 46 2	
1	II.	,,	Bisection	,,	21 48 30	21 50
1	II.	,,	Last seen	,,	21 51 54	
1	I.	Tr. Ingr.	Ext. contact	,,	23 48 33	
1	I.	,,	Bisection	,,	23 49 30	23 46
1	I.	,,	Int. contact	,,	23 50 50	
3	I.	Tr. Egr.	Ext. contact	,,	20 27 42	
3	I.	,,	Bisection	,,	20 29 12	20 30
3	I.	,,	Ext. contact	,,	20 32 7	
7	IV.	Occ. R.	Last contact	74	21 8 19	20 33
11	I.	Ecl. R.	First seen	,,	20 54 21	20 54 57

Day of Obs.	Satellite.	Phenomenon.	Phase.	Mag. Power.	G.M.T. of Observation.	Mean Time of *N. Almanac.*
					h m s	h m s
Mar. 18	I.	Ecl. R.	First seen	74	22 50 12	22 50 42
18	I.	,,	Full brightness	,,	22 53 50	
25	I.	Occ. D.	First contact	168	21 10 2	
25	I.	,,	Bisection	,,	21 12 26	21 13
25	I.	,,	Last seen	,,	21 13 36	
Apr. 3	I.	Ecl. R.	First seen	74	21 10 36	21 11 0
3	I.	,,	Full brightness	,,	21 14 26	
9	I.	Tr. Ingr.	Ext. contact	,,	22 17 28	
9	I.	,,	Bisection	,,	22 20 47	22 20
9	I.	,,	Int. contact	,,	22 23 37	
10	IV.	Ecl. R.	First seen	138	21 39 19	21 52 36
10	IV.	,,	Full brightness	,,	21 55 22	
20	II.	Ecl. R.	First seen	,,	21 3 34	21 4 45
20	II.	,,	Full brightness	,,	21 7 6	
24	III.	,,	First seen	,,	20 6 49	20 8 30
24	III.	,,	Full brightness	,,	20 14 36	
26	I.	,,	First seen	,,	21 26 27	21 26 41
May 12	I.	,,	First seen	74	19 45 55	19 46 13
12	I.	,,	Full brightness	,,	19 49 20	

Remarks.

Feb. 4.—Clear sky, but moon present.

Feb. 8.—Sky beautifully clear and images steady and well defined.

Feb. 11.—Sky clear and definition pretty good; the first phase observed rather late.

Feb. 12.—Steadiness and definition very satisfactory. First phase noted late; the satellite had certainly faded as compared with the other satellites. I thought I could again see the satellite for moment, eight seconds after the recorded time of disappearance.

Feb. 14.—Images rather tremulous, particularly at final disappearance.

Feb. 15.—II. suspected at recorded time; I was certain of it three seconds later. The planet had just emerged from a thin cloud. Definition of I. pretty good.

Feb. 22.—Good definition at external contact, but not so at bisection.

Feb. 23.—Sky beautifully clear with good definition; moon absent.

Mar. 1.—Planet badly defined and boiling. Bisection of III. very unsatisfactory; definition better at external contact. Images steady and fairly defined at ingress of I., but external contact noted rather late in consequence of cloud.

Mar. 3.—Images steady and well defined. The shadows of I. and II. were at the same time on the disc. The shadow of I., the further one from the centre of the disc, was projected on a bright zone, and appeared as a dark, hazy spot, while the shadow of II. was seen as a perfectly black spot on one of the dark belts of the planet.

Mar. 11.—Steadiness and definition satisfactory.

Mar. 18.—Clear sky, but images somewhat tremulous.

Mar. 25.—Fair definition.

Apr. 3.—Sky clear and definition good, but images slightly tremulous.

Apr. 9.—Planet low and boiling, and observations unsatisfactory.

Apr. 10.—Sky beautifully clear, and planet low; the images, however, were pretty steady and well defined. This was the first eclipse visible here of the new cycle. The observer's position was taken at the telescope about 16 min. before the time of the *Nautical Almanac*, and the satellite was first seen as a very small brownish speck.

Apr. 20.—Definition fairly good, but images slightly tremulous. Observation of first appearance possibly a second late.

Apr. 24.—Sky beautifully clear. On the whole the planet was pretty well defined, but the limb occasionally boiled.

Apr. 26.—Sky beautifully clear, but planet low and boiling.

May 12.—Sky beautifully clear, but twilight pretty strong; planet's limb occasionally boiled.

Note.—An occulting bar was not employed in the eclipse observations. The times given in the first and sixth columns are the Windsor mean times of observation diminished by $10^h\ 3^m\ 20^s{\cdot}5$ and entered to the nearest second. The observations of full brightness in the eclipses are at the best only roughly approximate. In determining these times the increasing light of the satellite was repeatedly compared with the other visible satellites.

Private Observatory, Windsor, N.S. Wales:
1895 *June* 22.

Results of Micrometer Comparisons of Saturn and κ Virginis, 1895 May. By John Tebbutt.

During the close approach of *Saturn* to *κ Virginis* in May last I availed myself of the opportunity for securing a careful series of filar micrometer comparisons of the planet with the 8-inch equatorial. Comparisons were made on six nights under the most satisfactory conditions, the images being steady and well defined. A magnifying power of 74 diameters was employed throughout. On each of the first five evenings ten comparisons of the planets *preceding* and *north*, and the same number of the *following* and *south* limbs were made, in order to eliminate as much as possible any effect due to an error of the tabular semidiameter of the planet. On the last evening five comparisons only were obtained of each pair of corresponding limbs. The differential measures have been corrected for the tabular semidiameter, refraction, and a small inclination of the transit thread to the meridian when the distance threads were set parallel to the equator. The star's mean place for 1895·0 has been adopted as R.A.$=14^h\ 7^m\ 17^s{\cdot}59$, N.P.D.$=99°\ 47'\ 5''{\cdot}8$ from the Greenwich Five-Year Catalogue of 258 Fundamental Stars for 1890. Considering the excellent conditions for observing, and the almost absolute accuracy of the place of the comparison star, I venture to think that the results as given in the accompanying table will prove as satisfactory as any derived from observations on the meridian. The last column of the table exhibits the resulting errors of the ephemeris on page 260 of the *Nautical Almanac*. The reductions plainly indicate that the semidiameter of the *Nautical Almanac* is somewhat too small. Measures of *Venus* and *ε Geminorum* were obtained on May 19 and 20, but the objects were so badly defined and tremulous that the results are scarcely worth publication.

Results of Micrometer Comparisons of Saturn and κ Virginis.

1895.	Windsor Mean Time.	Diff. R.A. Planet's Centre—Star.	Correction for Parallax.	Adopted Apparent R.A. of Star.	Geocentric Apparent R.A. of Planet's Centre from Observation.	*Nautical Almanac.*	Diff. *N.A.*—Obs.
	h m s	m s	s	h m s	h m s	s	s
May 6	10 7 7	− 0 19·94	−0·02	14 7 20·01	14 7 0·95	1·12	+0·17
7	8 45 49	− 0 34·9	−0·03	14 7 20·01	14 6 45·07	45·25	+0·18
9	9 21 42	− 1 8·62	−0·02	14 7 20·02	14 6 11·38	11·52	+0·14
13	8 26 38	− 2 13·09	−0·03	14 7 20·04	14 5 6·92	7·13	+0·21
15	8 34 15	− 2 44·81	−0·03	14 7 20·05	14 4 35·21	35·43	+0·22
16	8 50 56	− 3 0·40	−0·02	14 7 20·05	14 4 19·63	19·72	+0·09

1895.	Windsor Mean Time.	Diff. N.P.D. Planet's Centre —Star.	Correction for Parallax.	Adopted Apparent N.P.D. of Star.	Geocentric Apparent N.P.D. of Planet's Centre from Observation.	*Nautical Almanac.*	Diff. *N.A.*—Obs.
	h m s	′ ″	″	° ′ ″	° ′ ″	″	″
May 6	10 7 7	+ 11 19·8	+0·4	99 47 23·6	99 58 43·8	44·8	+1·0
7	8 45 49	+ 10 0·0	+0·4	99 47 23·6	99 57 24·0	25·3	+1·3
9	9 21 42	+ 7 11·7	+0·4	99 47 23·6	99 54 35·7	37·3	+1·6
13	8 26 38	+ 1 54·3	+0·4	99 47 23·6	99 49 18·3	20·1	+1·8
15	8 34 15	− 0 40·0	+0·4	99 47 23·6	99 46 44·0	46·1	+2·1
16	8 50 56	− 1 55·8	+0·4	99 47 23·6	99 45 28·2	30·1	+1·9

Private Observatory, Windsor, N. S. Wales:
1895 *June* 2.

Errata in Mr. Tebbutt's Measures of Double Stars, MONTHLY NOTICES, *March* 1895.

Page 308, opposite to Ref. No. 11 and under "Eyes," *for* P *read* R.

Page 310, opposite to Ref. No. 60 and under "Distance," *for* ·88 *read* 2·88.

Page 311, opposite to Ref. No. 64 and under "Hour Angles," *for* 3 7 W *read* 3 47 W.

Ephemeris for Physical Observations of Jupiter,

Greenwich Noon.	Position-angle of ℵ's Axis. P	L−O	Diff.	B	Annual Parallax. A−L	Apparent Diameter. Equat. 2a	Defect.	Polar. 2b
1896.								
Jan. 1	16°.570	351°.618	221	+0°.439	−4°.751	45″.75	0″.08	42″.88
3	16.494	351.397	229	.440	4.368	45.89	.07	43.01
5	16.416	351.168	236	.442	3.978	46.01	.06	43.13
7	16.335	350.932	243	.444	3.581	46.13	.05	43.23
9	16.251	350.689	248	.446	3.177	46.23	.04	43.33
11	16.164	350.441	254	+0.448	−2.768	46.32	0 03	43.41
13	16.076	350.187	258	.451	2.354	46.40	.02	43.49
15	15.986	349.929	262	.454	1.935	46.46	.01	43.55
17	15.894	349.667	265	.458	1.512	46.51	.00	43.59
19	15.800	349.402	266	.462	1.087	46.55	...	43.63
21	15.705	349.136	268	+0.466	−0.660	46.57	...	43.65
23	15.610	348.868	268	.470	−0.231	46.58	...	43.66
25	15.514	348.600	267	.474	+0.198	46.57	...	43.65
27	15.418	348.333	266	.479	0.626	46.56	...	43.63
29	15.322	348.067	263	.484	1.052	46 52	.00	43.60
31	15.226	347.804	261	+0.488	+1.476	46.48	0.01	43.56
Feb. 2	15.131	347.543	258	.493	1.897	46.42	.01	43.51
4	15.036	347.285	254	.498	2.315	46.35	.02	43.44
6	14.943	347.031	248	.503	2 730	46.26	.03	43.36
8	14.852	346.783	242	.508	3.138	46.16	.03	43.27
10	14.762	346.541	236	+0.513	+3.541	46.05	0 04	43.16
12	14.674	346.305	230	.518	3.937	45.93	.05	43.05
14	14.589	346.075	222	.524	4.327	45.80	.06	42.92
16	14.506	345.853	213	.529	4.709	45.65	.08	42 79
18	14.426	345.640	204	.534	5.082	45.50	.09	42.64
20	14.349	345.436	194	+0.538	+5.446	45.33	0.10	42.49
22	14.276	345.242	184	.543	5.800	45.16	.12	42.33
24	14.206	345.058	174	.548	6.144	44.98	.13	42.15
26	14.140	344.884	163	.552	6.478	44.78	.14	41.97

1895–96. (*Concluded.*) By A. Marth.

Greenwich Noon. 1896.	Brightness in Star Magn.	Longitude of ♃'s Central Meridian. (877°·90) I.	(870°·27) II.	Corr. for Phase.	Light-time.	A − O	B
	m	°	°	°	m	°	°
Jan. 1	−2·11	223·19	225·18	+0·10	36·407	346·8694	+0·6954
3	−2·12	179·27	166·01	·08	36·298	347·0305	·6870
5	−2·12	135·36	106·84	·07	36·199	347·1916	·6786
7	−2·13	91·45	47·67	·06	36·109	347·3526	·6701
9	−2·13	47·55	348 50	·04	36·030	347·5136	·6617
11	−2·14	3·64	289·33	+0·03	35·961	347·6745	+0·6532
13	−2·14	319·73	230·16	·02	35·901	347·8354	·6448
15	−2 14	275·82	170·99	·02	35·852	347·9962	·6364
17	−2·15	231·90	111·81	·01	35·813	348·1570	·6279
19	−2·15	187·98	52·63	·01	35·785	348·3178	·6195
21	−2·15	144·06	353·45	+0·00	35·767	348·4786	+0·6110
23	−2·15	100·13	294·76	...	35·760	348·6393	·6026
25	−2·15	56·20	235·07	...	35·764	348·8000	·5941
27	−2·15	12·26	175·87	...	35·778	348·9606	·5857
29	−2·15	328·31	116·66	·00	35·803	349·1211	·5772
31	−2·14	284·35	57·44	−0 01	35·838	349·2816	+0·5687
Feb. 2	−2·14	240·38	358·21	·02	35·884	349·4420	·5603
4	−2·14	196·40	298·97	·02	35·939	349·6024	·5518
6	−2·13	152·42	239·73	·03	36·005	349·7628	·5434
8	−2·13	108·42	180·47	·04	36·082	349·9232	·5349
10	−2·12	64·41	121·20	−0 05	36·168	350·0835	+0·5264
12	−2·11	20·39	61·92	·07	36·264	350·2437	·5180
14	−2·11	336·35	2·62	·08	36·370	350·4039	·5095
16	−2·10	292·30	303·32	·10	36·485	350·5641	·5011
18	−2·09	248·24	244·00	·11	36·609	350·7242	·4926
20	−2·08	204·16	184·66	−0·13	36·743	350·8843	+0·4841
22	−2·08	160·07	125·31	·15	36·885	351·0444	·4757
24	−2·07	115·96	65·94	·16	37·035	351·2044	·4672
26	−2·06	71·84	6·56	·18	37·194	351·3643	·4587

Greenwich Noon.	Position-angle of ♃'s Axis. P	L − O	Diff.	B	Annual Parallax. A − L	Apparent Diameter. Equat. 2a	Defect.	Polar. 2b
1896.	°	°		°	°	″	″	″
Feb. 28	14·078	344·721	153	+ ·556	+ 6·802	44·58	·16	41·79
Mar. 1	14·020	344·568	141	+ 0·560	+ 7·114	44·38	0·17	41·59
3	13·966	344·427	129	·564	7·415	44·16	·18	41·39
5	13·916	344·298	118	·568	7·704	43·94	·20	41·18
7	13·871	344·180	105	·571	7·981	43·72	·21	40·97
9	13·831	344·075	93	·574	8·246	43·49	·22	40·76
11	13·795	343·982	80	+ 0·577	+ 8·498	43·25	0·24	40·54
13	13·764	343·902	68	·580	8·738	43·01	·25	40·31
15	13·738	343·834	55	·582	8·966	42·77	·26	40·08
17	13·717	343·779	42	·584	9·181	42·52	·27	39·85
19	13·701	343·737	28	·586	9·382	42·27	·28	39·62
21	13·689	343·709	16	+ 0·587	+ 9·570	42·02	0·29	39·39
23	13·683	343·693	3	·588	9·745	41·77	·30	39·15
25	13·682	343·690	9	·589	9·908	41·52	·31	38·91
27	13·685	343·699	22	·590	10·058	41·27	·32	38·68
29	13·694	343·721	35	·590	10·195	41·01	·32	38·44
31	13·707	343·756	47	+ 0·590	+ 10·319	40·76	0·33	38·20
Apr. 2	13·725	343·803	60	·590	10·431	40·51	·33	37·96
4	13·748	343·863	72	·589	10·531	40·25	·34	37·73
6	13·776	343·935	83	·588	10·618	40·00	·34	37·49
8	13·808	344·018	96	·586	10·693	39·75	·35	37·26
10	13·845	344·114	108	+ 0·584	+ 10·757	39·50	0·35	37·02
12	13·886	344·222	120	·582	10·808	39·26	·35	36·79
14	13·932	344·342	131	·579	10·847	39·01	·35	36·56
16	13·982	344·473	142	·576	10·875	38·77	·35	36·34
18	14·036	344·615	154	·573	10·892	38·53	·35	36·11
20	14·095	344·769	164	+ 0·570	+ 10·898	38·30	0·35	35·89
22	14·158	344·933	174	·566	10·892	38·06	·34	35·67
24	14·224	345·107	185	·561	10·876	37·83	·34	35·46
26	14·294	345·292	194	·557	10·851	37·61	·34	35·25
28	14·367	345·486	205	·552	10·815	37·38	·33	35·04

Greenwich Noon.	Brightness in Star Magn.	Longitude of Ⅱ's Central Meridian. (877°·90) I.	(870°·27) II.	Corr. for Phase.	Light-time.	A−O	B
1896.	m	°	°	°	m	°	°
Feb. 28	−2·05	27·70	307·16	− ·20	37·361	351·5242	+ ·4502
Mar. 1	−2·03	343·55	247·75	−0·22	37·535	351·6841	+0·4417
3	−2·02	299·38	188·32	·24	37·717	351·8439	·4333
5	−2·01	255·19	128·87	·26	37·906	352·0037	·4248
7	−2·00	210·99	69·41	·28	38·102	352·1635	·4163
9	−1·99	166·77	9·93	·30	38·304	352·3232	·4078
11	−1·98	122·54	310·44	−0·32	38·513	352·4829	+0·3993
13	−1·96	78·29	250·93	·33	38·727	352·6425	·3908
15	−1·95	34·02	191·41	·35	38·947	352·8021	·3823
17	−1·94	349·74	131·87	·37	39·172	352·9617	·3738
19	−1·92	305·44	72·31	·38	39·402	353·1212	·3653
21	−1·91	261·13	12·74	−0·40	39·637	353·2807	+0·3568
23	−1·90	216·80	313·15	·41	39·876	353·4401	·3483
25	−1·88	172·45	253·54	·43	40·119	353·5995	·3398
27	−1·87	128·09	193·92	·44	40·365	353·7589	·3313
29	−1·86	83·72	134·29	·45	40·615	353·9182	·3228
31	−1·84	39·33	74·64	−0·46	40·867	354·0775	+0·3143
Apr. 2	−1·83	354·93	14·98	·47	41·123	354·2367	·3058
4	−1·81	310·51	315·31	·48	41·380	354·3959	·2973
6	−1·80	266·08	255·62	·49	41·640	354·5551	·2888
8	−1·79	221·64	195·92	·50	41·902	354·7142	·2803
10	−1·77	177·18	136·20	−0·50	42·165	354·8733	+0·2718
12	−1·76	132·71	76·47	·51	42·430	355·0323	·2633
14	−1·74	88·23	16·73	·51	42·696	355·1913	·2548
16	−1·73	43·74	316·98	·51	42·962	355·3503	·2463
18	−1·72	359·23	257·22	·52	43·228	355·5093	·2378
20	−1·70	314·71	197·45	−0·52	43·495	355·6682	+0·2293
22	−1·69	270·19	137·66	·52	43·761	355·8271	·2208
24	−1·68	225·65	77·86	·51	44·027	355·9859	·2123
26	−1·66	181·10	18·06	·51	44·293	356·1449	·2038
28	−1·65	136·55	318·25	·51	44·557	356·3034	·1953

Greenwich Noon.	Position-angle of ♃'s Axis. P	L−O.	Diff.	B	Annual Parallax. A−L.	Apparent Diameter. Equat. 2a	Defect.	Polar. 2b
1896.	°	°		°	°	″	″	″
Apr. 30	14·444	345·691	215	+0·547	+10·769	37·16	0·33	34·83
May 2	14·525	345·906	224	·541	10·713	36·95	·32	34·63
4	14·609	346·130	233	·535	10·647	36·74	·32	34·43
6	14·696	346·363	241	·529	10·573	36·53	·31	34·23
8	14·786	346·604	251	·523	10·490	36·32	·30	34·04
10	14·879	346·855	260	+0·516	+10·397	36·12	0·30	33·85
12	14·975	347·115	268	·508	10·296	35·92	·29	33·67
14	15·073	347·383	275	·500	10·187	35·73	·28	33·49
16	15·174	347·658	284	·492	10·069	35·54	·27	33·31
18	15·277	347·942	291	·484	9·944	35·36	·27	33·14
20	15·383	348·233	298	+0·475	+9·812	35·18	0·26	32·97
22	15·491	348·531	306	·466	9·672	35·00	·25	32·81
24	15·601	348·837	313	·457	9·524	34·83	·24	32·65
26	15·713	349·150	319	·448	9·370	34·67	·23	32·49
28	15·827	349·469	325	·438	9·209	34·50	·22	32·34
30	15·942	349·794	332	+0·428	+9·042	34·34	0·21	32·19
June 1	16·059	350·126	338	·417	8·868	34·19	·20	32·05
3	16·178	350·464	344	·407	8·688	34·04	·20	31·91
5	16·298	350·808	350	·396	8·502	33·90	·19	31·77
7	16·420	351·158	355	·385	8·310	33·76	·18	31·64
9	16·542	351·513	360	+0·373	+8·113	33·62	0·17	31·51
11	16·666	351·873	365	·361	7·911	33·49	·16	31·39
13	16·790	352·238	370	·349	7·703	33·36	·15	31·27
15	16·916	352·608	375	·336	7·490	33·24	·14	31·15
17	17·042	352·983	380	·324	7·273	33·12	·13	31·04
19	17·169	353·363	384	+0·311	+7·051	33·00	0·12	30·93
21	17·296	353·747		0·298	6·825	32·89	·12	30·83

Greenwich Noon.	Brightness in Star Magn.	Longitude of ♃'s Central Meridian. (877°·90) I.	(870°·27) II.	Corr. for Phase.	Light-time.	A−O	B
1896.	m	°	°	°	m	°	°
Apr. 30	−1·64	91·98	258·42	−0·50	44·821	356·4621	+0·1868
May 2	−1·62	47·41	198·59	·50	45·083	356·6208	·1783
4	−1·61	2·83	138·75	·49	45·343	356·7794	·1698
6	−1·60	318·24	78·90	·49	45·602	356·9380	·1613
8	−1·59	273·64	19·04	·48	45·859	357·0965	·1528
10	−1·57	229·03	319·17	−0·47	46·114	357·2550	+0·1443
12	−1·56	184·42	259·30	·46	46·366	357·4134	·1359
14	−1·55	139·80	199·42	·45	46·616	357·5718	·1274
16	−1·54	95·17	139·54	·44	46·863	357·7302	·1189
18	−1·53	50·54	79·65	·43	47·106	357·8886	·1104
20	−1·52	5·90	19·75	−0·42	47·347	358·0470	+0·1019
22	−1·50	321·26	319·85	·41	47·584	358·2053	·0935
24	−1·49	276·61	259·94	·39	47·818	358·3636	·0850
26	−1·48	231·96	200·03	·38	48·048	358·5218	·0765
28	−1·47	187·30	140·12	·37	48·274	358·6800	·0680
30	−1·46	142·64	80·20	−0·36	48·496	358·8381	+0·0595
June 1	−1·45	97·98	20·27	·34	48·715	358·9962	·0511
3	−1·44	53·31	320·35	·32	48·929	359·1542	·0426
5	−1·43	8·64	260·42	·31	49·138	359·3122	·0341
7	−1·43	323·96	200·48	·30	49·343	359·4702	·0256
9	−1·42	279·28	140·55	−0·29	49·543	359·6282	+0·0171
11	−1·41	234·60	80·61	·27	49·739	359·7861	·0087
13	−1·40	189·92	20·67	·26	49·930	359·9440	+0·0002
15	−1·39	145·24	320·73	·24	50·115	0·1018	−0·0083
17	−1·38	100·55	260·78	·23	50·295	0·2596	·0168
19	−1·38	55·87	200·84	−0·22	50·470	0·4173	−0·0253
21	−1·37	11·18	140·89	·20	50·640	0·5750	·0338

The following is a list (continued from p. 493) of Greenwich mean times when the zero-meridian in the assumed two systems of longitudes will pass the middle of the illuminated disc :—

1896.		I. (877°·90) h m	II. (870°·27) h m
Jan.	1	3 44·2	3 42·9
		13 34·6	13 38·5
	2	9 15·4	9 29·6
		19 5·8	19 25·2
	3	4 56·2	5 20·8
		14 46·7	15 16·4
	4	10 27·5	11 7·5
		20 17·9	21 3·1
	5	6 8·3	6 58·7
		15 58·7	16 54·3
	6	11 39·5	12 45·5
		21 30·9	22 41·0
	7	7 20·3	8 36·6
		17 10·7	18 32·2
	8	3 1·1	4 27·8
		12 51·5	14 23·4
	9	8 32·4	10 14·5
		18 22·8	20 10·1
	10	4 13·2	6 5·7
		14 3·6	16 1·3
	11	9 44·4	11 52·4
		19 34·8	21 48·0
	12	5 25·2	7 43·6
		15 15·6	17 39·2
	13	10 56·4	3 34·8
		20 46·8	13 30·4
	14	6 37·2	9 21·5
		16 27·6	19 17·1
	15	12 8·4	5 12·7
		21 58·8	15 8·3
	16	7 49·3	10 59·4
		17 39·7	20 55·0
	17	3 30·1	6 50·6
		13 20·5	16 46·2
	18	9 1·3	2 41·7
Jan.	18	12 7	Sat. III. Shadow crossing central Meridian.
		18 51·7	12 37·3
	19	4 42·1	8 28·5
		14 32·5	18 24·1
	20	10 13·3	4 19·7
		20 3·7	14 15·2
	21	5 54·1	10 6·4
		15 44·6	20 2·0
	22	11 25·4	5 57·6
		21 15·8	15 53·2
	23	7 6·2	11 44·3
		16 56·6	21 39·9
	24	2 47·0	7 35·5
		7 9	♃'s centre 84″·0 south of ✶ 9ᵐ·2 B.D. 20°·2106.
		12 37·4	17 31·1
		16 30	♃'s centre 47″·2 south of ✶ 9ᵐ·0 B.D. 20°·2104.
	25	8 18·2	3 26·7
		16 7	Sat. III. Sh.
		18 8·6	13 22·3
	26	3 59·1	9 13·4
		13 49·5	19 9·0
	27	9 30·3	5 4·6
		19 20·7	15 0·2
	28	5 11·1	10 51·4
		15 1·5	20 47·0
	29	10 42·4	6 42·6
		20 32·8	16 38·2
	30	6 23·3	2 33·8
		16 13·6	12 29·4
	31	2 4·1	8 20·6
		11 54·5	18 16·2
Feb.	1	7 35·4	4 11·8

1896.	I. (877°·90) h m	II. (870°·27) h m	1896.	I. (877°·90) h m	II. (870°·27) h m
Feb. 1	17 25 8	14 7·4	Feb. 19	8 34·9	8 59·0
	20 6	Sat. III. Sh.		18 25·4	18 54·7
2	3 16·2	9 58·6	20	4 15·8	4 50·3
	13 6·6	19 54·2		14 6·3	14 46·0
3	8 47·5	5 49·8	21	9 47·2	10 37·3
	18 37·9	15 45·4		19 37·7	20 32·9
4	4 28·3	11 36·6	22	5 28·2	6 28·6
	14 18 8	21 32·2		15 18·6	16 24·2
5	9 59·6	7 27 8	23	1 9·1	2 19·9
	19 50·1	17 23·4		8 4	Sat. III. Sh.
6	5 40·5	3 19·0		10 56·9	12 15·5
	15 30 9	13 14·6	24	6 40·5	8 6·8
7	11 11·8	9 5·9		16 31·0	18 2·5
	21 2·2	19 1·5	25	2 21·5	3 58·1
8	6 52·7	4 57·1		12 12·0	13 53·8
	16 43·1	14 52·7	26	7 52·9	9 45·1
9	2 33·6	10 43·9		17 43·4	19 40·8
	12 24·0	20 39·6	27	3 33·9	5 36·4
10	8 4·9	6 35·2		13 24·4	15 32·1
	17 55·3	16 30·8	28	9 5·4	1 27·8
11	3 45·8	2 26·4		18 55·9	11 23·4
	13 36·2	12 22·0	29	4 46·3	7 14·8
12	9 17·1	8 13·3		14 36·8	17 10·4
	19 7·6	18 8·9	Mar. 1	10 17·8	3 6·1
13	4 58·0	4 4·5		12 3	Sat. III. Sh.
	14 48·5	14 0·2		20 8·3	13 1·8
14	10 29·4	9 51·4	2	5 58·8	8 53·1
	18 20	Sat. IV. Sh.		12 22	Sat. IV. Sh.
	20 10·8	19 47·1		15 49·3	18 48·8
15	6 10·3	5 42·7	3	1 39·8	4 44·5
	16 0·7	15 38·3		11 30·3	14 40·1
16	1 51·2	1 33·9	4	7 11·4	10 31·5
	11 41·6	11 29·6		17 1·8	20 27·2
	21 32·1	21 25·2	5	2 52·3	6 22·9
17	7 22·6	7 20·8		12 42·9	16 18·6
	17 13·0	17 16·5	6	8 23·9	2 14·2
18	3 3·5	3 12·1		18 14·4	12 9·9
	12 53·9	13 7·7	7	4 4·9	8 1·3

1896.	I. (877°·90) h m	II. (870°·27) h m	1896.	I. (877°·90) h m	II. (870°·27) h m
Mar. 7	13 55·4	17 57·0	Mar. 25	14 58·9	12 52·6
8	9 36·4	3 52·7	26	10 40·0	8 44·1
	16 2	Sat. III. Sh.		20 30·6	18 39·8
	19 26·9	13 48·4	27	6 21·2	4 35·6
9	5 17·4	9 39·8		16 11·7	14 31·3
	15 8·0	19 35·4	28	2 2·3	10 22·8
10	10 49·0	5 31·1		11 52·8	20 18·5
	20 39·5	15 26·8	29	7 34·0	6 14·3
11	6 30·0	1 22·5		17 24·5	16 10·0
	16 20·5	11 18·2	30	3 15·1	2 5·7
12	2 11·1	7 9·6		13 5·7	12 1·5
	12 1·6	17 5·3	31	8 46·8	7 53·0
13	7 42·6	3 1·0		18 37·4	17 48·7
	17 33·2	12 56·7	Apr. 1	4 27·9	3 44·5
14	3 23·7	8 48·1		14 18·5	13 40·2
	13 14·2	18 43·8	2	9 59·7	9 31·7
15	8 55·3	4 39·6		19 50·2	19 27·5
	18 45·8	14 35·3	3	5 40·8	5 23·2
	20 2	Sat. III. Sh.		15 31·9	15 19·0
16	4 36·4	10 26·7	4	1 22·0	1 14·8
	14 26·9	20 22·4		11 12·5	11 10·5
17	10 8·0	6 18·1	5	6 53·7	7 2·0
	19 58·5	16 13·8		16 44·3	16 57·8
18	5 49·0	2 9·5	6	2 34·9	2 53·5
	15 39·6	12 5·3		8 1	Sat. III. Sh.
19	6 24	Sat. IV. Sh.		12 25·5	12 49·3
	11 20·7	7 56·7	7	8 6·6	8 49·8
	21 11·2	17 52·4		17 57·2	18 36·6
20	7 1·7	3 48·1	8	3 47·8	4 32·4
	16 52·3	13 43·9		13 38·4	14 28·1
21	2 42·8	9 35·3	9	9 19·6	10 19·7
	12 33·4	19 31·0	10	5 0·7	6 11·2
22	8 14·5	5 26·7		14 51·3	16 7·0
	18 5·0	15 22·5	11	10 32·5	11 58·5
23	3 55·6	1 18·2	12	6 13·7	7 50·1
	13 46·1	11 13·9		16 4·3	17 45·8
24	9 27·3	7 5·4	13	1 54·9	3 41·6
	19 17·8	17 1·1		12 1	Sat. III. Sh.
25	5 8·4	2 56·9		11 45·5	13 37·4

1896.	I. (877°·90) h m	II. (870°·27) h m	1896.	I. (877°·90) h m	II. (870°·27) h m
Apr. 14	7 26·7	9 28·9	May 15	11 33·9	10 14·0
15	3 7·9	5 20·5	16	7 15·2	16 1·4
	12 58·5	15 16·3	17	12 47·1	11 53·1
16	8 39·7	11 7·8	18	8 28·4	7 44·7
17	4 20·9	6 59·4	19	7 59	Sat. III. Sh.
	14 11·5	16 55·2		13 0·4	13 32·2
18	9 52·7	12 46·7	20	9 41·7	9 23·8
19	5 33·9	8 38·3	21	5 22·9	5 15·5
	15 24·5	18 34·1		15 13·6	15 11·3
20	11 5·8	14 25·7	22	10 54·9	11 2·9
	16 0	Sat. III. Sh.		15 53	4's centre 8″·1 south of ✶ 9ᵐ·0 B.D. 20°·2104 Occultation.
21	6 47·0	10 17·2			
22	2 28·2	6 8·8			
	12 18·8	16 4·6		20 45·5	20 58·8
23	8 0·0	11 56·2	23	0 4	4's centre 41″·3 south of ✶ 9ᵐ·2 B.D. 20°·2106.
24	3 41·3	7 47·8			
	13 31·9	17 43·6		6 36·2	6 54·6
25	9 13·1	13 35·2		16 26·8	16 50·4
26	4 54·3	9 26·7	24	12 8·1	12 42·1
27	10 26·2	15 14·1	25	6 32	Sat. IV. Sh.
28	6 7·4	11 5·7		7 49·4	8 33·7
29	11 39·3	6 57·3	26	11 58	Sat. III. Sh.
30	7 20·5	12 44·7		13 21·4	14 21·2
May 1	12 52·4	8 36·3	27	9 2·7	10 12·9
2	8 33·6	14 23·8	28	14 34·6	16 0·4
3	14 5·5	10 15·4	29	10 15·9	11 52·0
4	9 46·8	6 7·0	30	5 57·2	7 43·7
5	5 28·0	11 54·4	31	11 29·1	13 31·2
6	10 59·9	7 46·0	June 1	7 10·4	9 22·8
7	6 41·2	13 33·5	2	12 42·4	15 10·3
8	12 13·1	9 25·1		15 57	Sat. III. Sh.
	12 31	Sat. IV. Sh.	3	8 23·7	11 2·0
9	7 54·4	5 16·7	4	13 55·7	6 53·7
	17 45·0	15 12·5	5	9 37·0	12 41·2
10	13 26·3	11 4·2	6	5 18·3	8 32·8
11	9 7·5	6 55·8	7	10 50·3	14 20·3
12	14 39·5	12 43·2	8	6 31·6	10 12·0
13	10 20·7	8 34·9	9	12 3·6	15 59·5
	6 2·0	14 22·3	10	7 44·9	11 51·2

1896.	I. (877°·90) h m	II. (870°·27) h m	1896.	I. (877°·90) h m	II. (870°·27) h m
June 11	13 16·8	7 42·9	June 14	10 11·4	15 9·6
12	8 58·2	13 30·4	15	5 52·8	11 1·2
13	4 39·5	9 22·0	16	11 24·7	6 52·9
14	9	Occultation of ♃'s system by the Moon—*V.* next paper.	17	7 6·0	12 40·4
			18	12 38·0	8 32·1

The intervals between successive passages of the zero-meridian vary in System I. between $9^h\ 50^m{\cdot}40$ and $50^m{\cdot}66$, and in II. between $9^h\ 55^m{\cdot}58$ and $55^m{\cdot}84$. The differences of successive values of the longitudes of ♃'s Central Meridian for the two-days interval vary in System I. between 1755°·31 and 1756°·10, and in II. between 1740°·05 and 1740°·83.

If, on *Jupiter's* spheroidal surface, ω is the (jovicentrically western) longitude of a spot or marking in the adopted system of longitudes, ω_0 that of the central meridian, and β' the latitude of the spot, the apparent co-ordinates x and y of the spot, referred to the semiaxes a and b of the disc, are :

$$x = a \cos \beta' \sin (\omega - \omega_0)$$
$$y = b \sin (\beta - B') + x \sin B \tan \tfrac{1}{2} (\omega - \omega_0)$$

where $\tan B' = \tan B \sec \varepsilon_0$. The values of ω and β' are, of course, best determined when the spot is crossing the central meridian, so that

$$\omega = \omega_0$$

and

$$\sin (\beta' - B') = \frac{y}{b}.$$

The jovicentric latitude β of the spot is connected with β' by $\tan \beta = \tan \beta' \cos \varepsilon_0$, but it is not needed, as in practice it is sufficient to know β', the jovicentric latitude of the point, where the sphere round the polar axis as diameter is cut by the perpendicular line from the spot upon the polar axis. The latitude B being small, B′ is found by adding to B one fifteenth part.

The occultation of a star $9^m{\cdot}0$ by *Jupiter* on May 22 will be observable in the greater part of North America. Assuming the apparent place of the star to be $\alpha\ 8^h\ 26^m\ 9^s{\cdot}4$, $\delta + 19°\ 55'\ 33''{\cdot}7$, derived from the lately published "Catalog der Astron. Gesellschaft, Zehntes Stück," and referring its apparent position to the axes of *Jupiter's* disc, the star will be in conjunction with the following lighted border of the disc, May 22 : $15^h\ 2^m$ Gr., $8''{\cdot}4$ north, and with the preceding limb at $16^h\ 33^m$ Gr., $7''{\cdot}4$ north. The occultation of the star by *Jupiter* takes place, geocentrically, from $15^h\ 8^m$ to $16^h\ 28^m$ Gr. The effect of parallax will be to retard these times some minutes, and to shorten the duration. The disappearance of the star behind the not fully illuminated limb will be visible in North America, except in the western States, where it occurs too near sunset. But observers in the

west may watch the conjunction of the star with Sat. II., which occurs, geocentrically, at $16^h\ 52^m$ Gr., the satellite passing $7''{\cdot}0$ south of the star. The conjunction of the star with Sat. I. occurs earlier in the night, at $11^h\ 40^m$ Gr., the satellite passing $11''{\cdot}0$ south, too late for European, too early for American, observers.

The measurements of the *fifth* satellite, which Prof. Barnard has secured during its third apparition on eight nights (October 8, 29, November 4, 11, 12, 18, 19, December 3, 1894) and which he has kindly communicated before publication, leave the correction required by the ephemeris in No. 3,253 of the *Astron. Nachrichten* rather undecided, so that for the present ephemeris I have made no change in the adopted daily rate of motion $722°{\cdot}633$, which corresponds to a period of $11^h\ 57^m\ 22^s{\cdot}60$. No other measurements made during last season have come to my knowledge.

Ephemeris of the Fifth Satellite of Jupiter, 1895–96.

Greenwich Noon.	P+90°.	a_s	b_s	l_s-L_s	Greenwich Times of greatest Elongations.	
1895.	°	″	″	°	h m	h m
Oct. 21	106·61	47·00	+0·55	185·85	14 45 W.	20 44 E.
23	106·68	47·27	·54	191·04	14 35	20 33
25	106·75	47·55	·53	196·24	14 24	20 23
27	106·81	47·83	·53	201·45	14 14	20 13
29	106·87	48·12	·52	206·67	14 4	20 2
31	106·93	48·41	·51	211·91	13 53 W.	19 52 E.
Nov. 2	106·98	48·70	+0·51	217·15	13 43	19 41
4	107·03	49·00	·50	222·41	13 32	19 31
6	107·07	49·30	·49	227·67	13 22	19 20
8	107·11	49·60	·49	232·95	13 11	19 10
10	107·15	49·90	·48	238·24	13 1 W.	18 59 E.
12	107·18	50·21	+0·48	243·55	18 49 E.	24 47 W.
14	107·20	50·52	·47	248·86	18 38	24 37
16	107·22	50·83	·47	254·19	18 28	24 26
18	107·24	51·14	·46	259·52	18 17	24 16
20	107·26	51·46	·46	264·87	18 6	24 5
22	107·27	51·77	+0·45	270·23	17 56 E.	23 54 W.
24	107·27	52·08	·45	275·61	17 45	23 43
26	107·27	52·39	·45	280·99	17 34	23 33
28	107·27	52·70	·44	286·38	17 23	23 22
30	107·26	53·01	·44	291·79	17 13	23 11
Dec. 2	107·25	53·31	+0·44	297·21	17 2 E.	23 0 W.
4	107·23	53·61	·44	302·63	16 51	22 50
6	107·21	53·91	·43	308·07	16 40	22 39
8	107·19	54·20	·43	313·52	16 29	22 28
10	107·16	54·49	·43	318·98	16 18	22 17

Greenwich Noon.	P + 90°.	a_s	b_s	$l_s - L$.	Greenwich Times of greatest Elongations.	
1895.	°	″	″	°	h m	h m
Dec. 12	107·13	54·77	+0·43	324·44	16 7 E.	22 6 W.
14	107·09	55·05	·43	329·92	15 56	21 55
16	107·05	55·32	·43	335·41	15 46	21 44
18	107·00	55·58	·43	340·90	15 35	21 33
20	106·95	55·83	·43	346·40	15 24	21 22
22	106·90	56·07	+0·43	351·91	15 13 E.	21 11 W.
24	106·84	56·30	·43	357·43	15 2	21 0
26	106·78	56·52	·43	2·95	14 51	20 49
28	106·71	56·73	·43	8·48	14 40	20 38
30	106·64	56·93	·43	14·01	14 29	20 27
1896.						
Jan. 1	106·57	57·11	+0·44	19·55	14 18 E.	20 16 W.
3	106·49	57·28	·44	25·09	14 7	20 5
5	106·42	57·44	·44	30·64	13 55	19 54
7	106·34	57·58	·45	36·18	13 44	19 43
9	106·25	57·71	·45	41·73	13 33	19 32
11	106·16	57·82	+0·45	47·28	13 22 E.	19 21 W.
13	106·08	57·92	·46	52·83	13 11	19 10
15	105·99	58·00	·46	58·38	13 0	18 59
17	105·89	58·06	·46	63·93	12 49	18 48
19	105·80	58·11	·47	69·47	12 38	18 37
21	105·71	58·13	+0·47	75·01	12 27 E.	18 26 W.
23	105·61	58·15	·48	80·55	12 16	18 15
25	105·51	58·14	·48	86·08	12 5	18 4
27	105·42	58·12	·49	91·61	11 54	17 53
29	105·32	58·08	·49	97·13	11 43	17 42
31	105·23	58·02	+0·49	102·64	11 32 E.	17 31 W.
Feb. 2	105·13	57·95	·50	108·15	11 21	17 20
4	105·04	57·86	·50	113·64	11 10	17 9
6	104·94	57·75	·51	119·13	10 59	16 58
8	104·85	57·63	·51	124·60	10 48	16 47
10	104·76	57·49	+0·51	130·07	10 37 E.	16 36 W.
12	104·67	57·34	·52	135·52	10 27	16 25
14	104·59	57·17	·52	140·97	10 16	16 14
16	104·51	56·99	·53	146·40	10 5	16 4
18	104·43	56·80	·53	151·81	9 54	15 53
20	104·35	56·59	+0·53	157·21	9 43 E.	15 42 W.
22	104·28	56·37	·53	162·60	9 33	15 31
24	104·21	56·14	·54	167·98	9 22	15 21
26	104·14	55·90	·54	173·34	9 11	15 10

Greenwich Noon. 1896.	P+90°.	a_s	b_s	l_s-L.	Greenwich Times of greatest Elongations.	
	°	″	″	°	h m	h m
Feb. 28	104·08	55·65	·54	178·69	9 1	14 59
Mar. 1	104·02	55·40	+0·54	184·02	8 50 E.	14 49 W.
3	103·97	55·13	·54	189·33	8 39	14 38
5	103·92	54·85	·54	194·63	8 29	14 28
7	103·87	54·57	·54	199·92	8 18	14 17
9	103·83	54·28	·54	205·19	8 8	14 7
11	103·79	53·99	+0·54	210·44	7 57 E.	13 56 W.
13	103·76	53·69	·54	215·68	7 47	13 46
15	103·74	53·39	·54	220·90	7 37	13 35
17	103·72	53·08	·54	226·11	7 26	13 25
19	103·70	52·77	·54	231·30	7 16	13 15
21	103·69	52·46	+0·54	236·48	7 6 E.	13 4 W.
23	103·68	52·14	·54	241·64	6 55	12 54
25	103·68	51·83	·53	246·79	6 45	12 44
27	103·68	51·51	·53	251·92	6 35	12 33
29	103·69	51·20	·53	257·04	6 25	12 23
31	103·71	50·88	+0·52	262·15	6 14 E.	12 13 W.
Apr. 2	103·73	50·56	·52	267·24	12 3 W.	18 2 E.
4	103·75	50·25	·52	272·31	11 53	17 52
6	103·78	49·93	·51	277·38	11 43	17 42
8	103·81	49·62	·51	282·43	11 33	17 31
10	103·85	49·31	+0·50	287·47	11 23 W.	17 21 E.
12	103·89	49·01	·50	292·49	11 13	17 11
14	103·93	48·70	·49	297·50	11 3	17 1
16	103·98	48·40	·49	302·50	10 53	16 51
18	104·04	48·10	·48	307·50	10 43	16 42
20	104·10	47·80	+0·48	312·49	10 33 W.	16 32 E.
22	104·16	47·51	·47	317·44	10 23	16 22
24	104·22	47·23	·46	322·40	10 13	16 12
26	104·29	46·95	·46	327·35	10 3	16 2
28	104·37	46·67	·45	332·29	9 53	15 52
30	104·44	46·39	+0·44	337·22	9 44 W.	15 42 E.

The differences between successive values of l_s-L for the interval of two days vary between 1444°·93 and 1445°·55. The values are to be interpolated for the times at which the rectangular co-ordinates are measured, when the corresponding computed co-ordinates will be

$$x_s = a_s \sin (l_s - L) \text{ in pos. angle } P + 90°$$
$$y_s = b_s \cos (l_s - L) \quad ,, \quad ,, \quad P.$$

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Data for computing the Positions of the Satellites of Jupiter, 1895–96. By A. Marth.

The following data for computing the places of the satellites for the present apparition of *Jupiter* are a continuation of those for the four preceding apparitions published in the *Monthly Notices*. They furnish, at intervals of ten days, the mean longitudes l of the satellites and the arguments of their inequalities. The motions of the longitudes and arguments during the intervals, and the inequalities corresponding to the arguments are to be found on pp. 524–539 of vol. li.

The inclinations γ and the longitudes of the nodes Γ of the planes of the orbits referred to the plane of *Jupiter's* equator are the following :—

		Sat. I.		Sat. II.		Sat. III.		Sat. IV.	
		γ_1	$O-\Gamma_1$	γ_2	$O-\Gamma_2$	γ_3	$O-\Gamma_3$	γ_4	$O-\Gamma_4$
1895.		°	°	°	°	°	°	°	°
Aug.	24	0·0099	169·3	0·4832	167·93	0·1256	129·58	0·3389	28·63
Sept.	23	99	170·7	·4830	168·92	·1257	129·78	·3386	28·68
Oct.	23	99	172·1	·4828	169·92	·1258	129·98	·3383	28·75
Nov.	22	99	173·5	·4826	170·91	·1259	130·17	·3381	28·81
Dec.	22	99	174·9	·4825	171·90	·1259	130·35	·3379	28·88
1896									
Jan.	21	0·0099	176·3	0·4823	172·88	0·1260	130·53	0·3378	28·95
Feb.	20	99	177·7	·4821	173·86	·1261	130·71	·3377	29·02
Mar.	21	98	179·0	·4819	174·83	·1262	130·88	·3376	29·09
Apr.	20	98	180·4	·4817	175·80	·1262	131·04	·3376	29·16
May	20	98	181·7	·4816	176·76	·1263	131·20	·3376	29·24
June	19	0·0098	183·0	0·4814	177·71	0·1264	131·35	0·3377	29·32

In a "Note on the Determination of the Planes of the Orbits of *Jupiter's* Satellites," published in vol. xliv. p. 241 ff., it was pointed out that the most promising means for determining the longitudes of the nodes of the orbits with accuracy would be found in micrometrical measurements of the rectangular coordinates of the shadows of the satellites near their midtransits, if these measurements are made about the times when the planes of the orbits pass through the Sun. Though the opportunities of 1884, and at the next nodal passages in 1890, pointed out in vol. l. p. 347, appear to have been neglected, observers ought to be reminded of their opportunities offered during the present apparition of *Jupiter*. The nodal passages occur, indeed, too late in the season to allow corresponding observations to be made on both sides of the centre, and when *Jupiter* becomes accessible again after the conjunction with the Sun, the shadows will cross at greater distances from the centre. After another revolution of *Jupiter*, in 1908, the circumstances will be rather more favourable, but the best opportunities for getting corresponding observations before and after the nodal passages will only present themselves during the oppositions of 1920 and 1932. But, at the opposite node, the most favourable opportunities during *Jupiter's* 83 years' cycle will offer themselves in 1902 and 1914, and,

though *Jupiter* will then have considerable southern declination, it is to be hoped the opportunities will not again be neglected. At present it is unknown what degree of accuracy is attainable in measuring the co-ordinates of the shadows. It would be mere waste of labour to give accurate predictions, but I am willing to compute the measures of the shadows made during the present apparition, if they are published or communicated in time.

The rectangular co-ordinates of the satellites referred to the axes of the disc of *Jupiter* are found by means of the formulæ (*v.* vol. li. p. 506) :

$$\Delta' = \Delta + a\rho \cos \mathrm{B} \,.\, \cos (v - \mathrm{L})$$

$$x = \frac{a''}{\Delta'} \,.\, \rho \,.\, \sin (v - \mathrm{L})$$

$$y = \frac{a''}{\Delta'} \,.\, \rho \left(\cos (v - \mathrm{L}) \sin \mathrm{B} + \sin \gamma \cos \mathrm{B} \,.\, \sin (v - \Gamma) \right).$$

The values of the distance Δ of *Jupiter* from the Earth and of L and B are to be interpolated for the times t, for which the positions are required, but those of l' and of the arguments on which the true longitudes v and the rad. vect. ρ depend, for the times $t - \tau$, if τ is the light-time given in the ephemeris for physical observations.

As there will be an occultation of *Jupiter's* system by the Moon on June 14, I have computed the positions of the satellites and give here the results :

1896 June 14.		Sat. I.		Sat. II.		Sat. III.		Sat. IV.	
		x_1	y_1	x_2	y_2	x_3	y_3	x_4	y_4
h	m	″	″	″	″	″	″	″	″
9	0 Gr.	+96·18	+0·03	+124·55	−1·71	+202·68	+0·82	−425·44	−2·81
9	30	96·50	−0·01	121·14	1·71	205·15	0·79	426·01	2·78
10	0	96·29	0·05	117·58	1·72	207·55	0·76	426·55	2·75
10	30	95·54	0·09	113·87	1·72	209·88	0·73	427·07	2·72
11	0	+94·27	−0·13	+110·00	−1·71	+212·15	+0·69	−427·56	−2·70

To convert these co-ordinates into differences of right ascension and declination, we have

$$s \sin (p - \mathrm{P}) = x \qquad 15 \cos \delta \, (\alpha - \mathrm{A}) = s \sin p$$

$$s \cos (p - \mathrm{P}) = y \qquad \delta - \mathrm{D} = s \cos p$$

Hence

		$\alpha_1 - \mathrm{A}$	$\delta_1 - \mathrm{D}$	$\alpha_2 - \mathrm{A}$	$\delta_2 - \mathrm{D}$	$\alpha_3 - \mathrm{A}$	$\delta_3 - \mathrm{A}$	$\alpha_4 - \mathrm{A}$	$\delta_4 - \mathrm{A}$
h	m	s	″	s	″	s	″	s	″
9	0 Gr.	+6·488	−27·89	+8·270	−37·80	+13·688	−58·06	−28·762	+120·82
9	30	6·508	28·03	8·137	36·81	13·854	58·81	28·799	121·03
10	0	6·493	28·02	7·896	35·78	14·015	59·54	28·834	121·22
10	30	6·443	27·84	7·645	34·71	14·171	60·25	28·868	121·40
11	0	+6·356	−27·51	+7·384	−33·58	+14·323	−60·95	−28·901	+121·58

The values of the mean distances of the satellites here assumed are those corresponding to the mass of *Jupiter's* system 1 : 1047·7. If it is preferred to adopt another mass, all these numbers must be multiplied by a factor, the logarithm of which may be inferred from the values in vol. li. p. 516.

First Satellite.

Greenwich Noon.		Longitude. l_1-O	S_1	Arguments. α_1	β_1	γ_1	δ_1	ϵ_1
1895.		°	°					
Aug.	24	99·5680	+·0014	·2296	·807	·033	·677	·197
Sept.	3	334·4575	13	·9026	·226	·681	·330	·222
	13	209·3471	13	·5757	·644	·329	·982	·246
	23	84·2366	12	·2487	·062	·978	·634	·271
Oct.	3	319·1262	11	·9217	·480	·626	·287	·296
	13	194·0158	10	·5947	·899	·274	·939	·320
	23	68·9053	+·0010	·2677	·317	·923	·591	·345
Nov.	2	303·7949	09	·9407	·735	·571	·243	·370
	12	178·6844	08	·6137	·153	·219	·896	·395
	22	53·5740	07	·2867	·572	·868	·548	·419
Dec.	2	288·4636	07	·9598	·990	·516	·200	·444
	12	163·3531	06	·6328	·408	·164	·852	·469
	22	38 2427	+·0005	·3058	·826	·812	·505	·493
1896.								
Jan.	1	273·1322	05	·9788	·245	·461	·157	·518
	11	148·0218	04	·6518	·663	·109	·809	·543
	21	22·9114	03	·3248	·081	·757	·461	·567
	31	257·8009	02	·9978	·499	·406	·114	·592
Feb.	10	132·6905	02	·6708	·918	·054	·766	·617
	20	7·5800	+·0001	·3439	·336	·702	·418	·641
Mar.	1	242·4696	+·0000	·0169	·754	·351	·071	·666
	11	117·3592	−·0000	·6899	·172	·999	·723	·691
	21	352·2487	01	·3629	·591	·647	·375	·715
	31	227·1383	02	·0359	·009	·296	·027	·740
Apr.	10	102·0278	03	·7089	·427	944	·680	·765
	20	336 9174	−·0003	·3819	·845	·592	·332	·790
	30	211·8070	04	·0549	·264	·241	·984	·814
May	10	86·6965	05	·7280	·682	·889	·636	·839
	20	321·5861	06	·4010	·100	·537	·289	·864
	30	196·4756	06	·0740	·518	·186	·941	·888
June	9	71·3652	07	·7470	·937	·834	·593	·913
	19	306·2548	−·0008	·4200	·355	·482	·246	·938
	29	181·1443	08	·0930	·773	·131	·898	·962

Greenwich Noon.	*First Satellite.* Arguments. ζ_1	η_1	θ_1	*Second Satellite.* Longitude. $l_2 - O$	S_2	Arguments. α_2	β_2
1895.				°			
Aug. 24	·752	·052	·869	58·2345	−·0089	·61482	·807
Sept. 3	·773	·073	·889	351·9818	89	·45132	·226
13	·795	·094	·910	285·7290	89	·28783	·644
23	·817	·114	·930	219·4763	89	·12433	·062
Oct. 3	·839	·135	·951	153·2235	89	·96084	·480
13	·860	·156	·972	86·9708	89	·79735	·899
23	·882	·177	·992	20·7180	−·0089	·63385	·317
Nov. 2	·904	·197	·013	314·4653	89	·47036	·735
12	·926	·218	·033	248·2125	89	·30687	·153
22	·947	·239	·054	181·9598	89	·14337	·572
Dec. 2	·969	·260	·074	115·7071	89	·97988	·990
12	·991	·280	·095	49·4543	89	·81639	·408
22	·013	·301	·116	343·2016	−·0089	·65289	·826
1896.							
Jan. 1	·034	·322	·136	276·9488	89	·48940	·245
11	·056	·343	·157	210·6961	89	·32590	·663
21	·078	·363	·177	144·4433	89	·16241	·081
31	·100	·384	·198	78·1906	89	·99892	·499
Feb. 10	·121	·405	·219	11·9378	89	·83542	·918
20	·143	·426	·239	305·6851	−·0088	·67193	·336
Mar. 1	·165	·446	·260	239·4324	88	·50844	·754
11	·187	·467	·280	173·1796	88	·34494	·172
21	·208	·488	·301	106·9269	88	·18145	·591
31	·230	·509	·322	40·6741	87	·01796	·009
Apr. 10	·252	·529	·342	334·4214	87	·85446	·427
20	·274	·550	·363	268·1686	−·0087	·69097	·845
30	·295	·571	·383	201·9159	86	·52748	·264
May 10	·317	·591	·404	135·6632	86	·36398	·682
20	·339	·612	·425	69·4104	86	·20049	·100
30	·361	·633	·445	3·1577	85	·03699	·518
June 9	·382	·654	·466	296·9049	85	·87350	·937
19	·404	·674	·486	230·6522	−·0084	·71001	·355
29	·426	·695	·507	164·3994	84	·54651	·773

Second Satellite.

Greenwich Noon.	Arguments. γ_2	δ_2	ϵ_2	ζ_2	η_2	θ_2	ι_2	κ_2	λ_2
1895.									
Aug. 24	·863	·563	·746	·752	·552	·369	·697	·667	·483
Sept. 3	·678	·378	·562	·773	·573	·389	·722	·524	·340
13	·493	·194	·378	·795	·594	·410	·746	·382	·198
23	·307	·010	·194	·817	·614	·430	·771	·239	·055
Oct. 3	·122	·826	·010	·839	·635	·451	·796	·096	·912
13	·937	·641	·826	·860	·656	·472	·820	·953	·769
23	·752	·457	·642	·882	·677	·492	·845	·811	·626
Nov. 2	·566	·273	·458	·904	·697	·513	·870	·668	·483
12	·381	·089	·274	·926	·718	·533	·895	·525	·340
22	·196	·904	·089	·947	·739	·554	·919	·382	·197
Dec. 2	·011	·720	·905	·969	·760	·574	·944	·239	·054
12	·826	·536	·721	·991	·780	·595	·969	·097	·911
22	·640	·352	·537	·013	·801	·616	·993	·954	·769
1896.									
Jan. 1	·455	·168	·353	·034	·822	·636	·018	·811	·626
11	·270	·983	·169	·056	·843	·657	·043	·668	·483
21	·085	·799	·985	·078	·863	·677	·067	·526	·340
31	·899	·615	·801	·100	·884	·698	·092	·383	·197
Feb. 10	·714	·431	·617	·121	·905	·719	·117	·240	·054
20	·529	·246	·433	·143	·926	·739	·141	·097	·911
Mar. 1	·344	·362	·249	·165	·946	·760	·166	·955	·768
11	·158	·878	·064	·187	·967	·780	·191	·812	·625
21	·973	·694	·880	·208	·988	·801	·215	·669	·483
31	·788	·509	·696	·230	·009	·822	·240	·526	·340
Apr. 10	·603	·325	·512	·252	·029	·842	·265	·384	·197
20	·417	·141	·328	·274	·050	·863	·290	·241	·054
30	·232	·957	·144	·295	·071	·883	·314	·098	·911
May 10	·047	·772	·960	·317	·091	·904	·339	·955	·768
20	·862	·588	·776	·339	·112	·925	·364	·813	·625
30	·676	·404	·592	·361	·133	·945	·388	·670	·482
June 9	·491	·220	·408	·382	·154	·966	·413	·527	·339
19	·306	·036	·224	·404	·174	·986	·438	·384	·196
29	·121	·851	·039	·426	·195	·007	·462	·242	·054

Third Satellite.

Greenwich Noon.		Longitude. $l_3 - O$	S_3	Arguments. α_3	β_3	γ_3	δ_3	ϵ_3
1895.		°	°					
Aug.	24	307·5678	−·0116	·2552	·4389	·8074	·352	·860
Sept.	3	90·7439	·0116	·6527	·8365	·2257	·150	·299
	13	233·9200	·0116	·0502	·2342	·6439	·949	·738
	23	17·0961	·0115	·4477	·6318	·0622	·747	·177
Oct.	3	160·2722	·0115	·8453	·0295	·4804	·546	·616
	13	303·4483	·0115	·2428	·4272	·8987	·344	·055
	23	86·6244	−·0115	·6403	·8248	·3169	·143	·494
Nov.	2	229·8005	·0115	·0378	·2225	·7352	·941	·933
	12	12·9766	·0114	·4353	·6201	·1534	·740	·372
	22	156·1527	·0114	·8328	·0179	·5717	·538	·811
Dec.	2	299·3288	·0114	·2303	·4154	·9899	·337	·250
	12	82·5049	·0114	·6278	·8131	·4082	·135	·689
	22	225·6810	−·0113	·0253	·2108	·8264	·933	·128
1896.								
Jan.	1	8·8571	·0113	·4229	·6084	·2447	·732	·567
	11	152·0332	·0112	·8204	·0061	·6630	·531	·006
	21	295·2093	·0112	·2179	·4037	·0812	·329	·445
	31	78·3854	·0111	·6154	·8014	·4995	·128	·884
Feb.	10	221·5615	·0111	·0129	·1990	·9177	·926	·323
	20	4·7376	−·0110	·4104	·5967	·3360	·725	·762
Mar.	1	147·9137	·0110	·8079	·9944	·7542	·524	·201
	11	291·0898	·0109	·2054	·3920	·1725	·322	·640
	21	74·2659	·0109	·6029	·7897	·5907	·121	·079
	31	217·4421	·0108	·0005	·1873	·0090	·919	·517
Apr.	10	0·6182	·0107	·3980	·5850	·4272	·718	·956
	20	143·7943	−·0107	·7955	·9826	·8455	·516	·395
	30	286·9704	·0106	·1930	·3803	·2637	·315	·834
May	10	70·1465	·0105	·5905	·7780	·6820	·113	·273
	20	213·3226	·0105	·9880	·1756	·1002	·912	·712
	30	356·4987	·0104	·3855	·5733	·5185	·710	·151
June	9	139·6748	·0103	·7830	·9709	·9368	·509	·590
	19	282·8509	−·0102	·1805	·3686	·3550	·307	·029
	29	66·0270	·0101	·5781	·7662	·7733	·106	·468

Greenwich Noon.		*Third Satellite.* Arguments. ζ_3	η_3	θ_3	ι_3	*Fourth Satellite.* Longitude. l_4-O	S_4	Arg. α_4
1895.						°	°	
Aug.	24	·752	·052	·869	·056	0·9428	−·0359	·58714
Sept.	3	·773	·073	·889	·452	216·6536	·0359	·18628
	13	·795	·094	·910	·849	72·3643	·0358	·78542
	23	·817	·114	·930	·245	288·0751	·0358	·38457
Oct.	3	·839	·135	·951	·642	143·7858	·0357	·98371
	13	·860	·156	·972	·038	359·4965	·0357	·58285
	23	·882	·177	·992	·435	215·2073	−·0356	·18199
Nov.	2	·904	·197	·013	·831	70·9180	·0356	·78113
	12	·926	·218	·033	·228	286·6288	·0355	·38028
	22	·947	·239	·054	·624	142·3395	·0354	·97942
Dec.	2	·969	·260	·074	·021	358·0502	·0353	·57856
	12	·991	·280	·095	·417	213·7610	·0352	·17770
	22	·013	·301	·116	·814	69·4717	−·0351	·77684
1896.								
Jan.	1	·034	·322	·136	·210	285·1825	·0350	·37599
	11	·056	·343	·157	·607	140·8932	·0349	·97513
	21	·078	·363	·177	·003	356·6039	·0348	·57427
	31	·100	·384	·198	·400	212·3147	·0346	·17341
Feb.	10	·121	·405	·219	·796	68·0254	·0345	·77255
	20	·143	·426	·239	·193	283·7362	−·0344	·37170
Mar.	1	·165	·446	·260	·589	139·4469	·0342	·97084
	11	·187	·467	·280	·986	355·1576	·0341	·56998
	21	·208	·488	·301	·382	210·8684	·0339	·16912
	31	·230	·509	·322	·779	66·5791	·0337	·76826
Apr.	10	·252	·529	·342	·175	282·2899	·0336	·36741
	20	·274	·550	·363	·572	138·0006	−·0334	·96655
	30	·295	·571	·383	·968	353·7113	·0332	·56569
May	10	·317	·591	·404	·365	209·4221	·0330	·16483
	20	·339	·612	·425	·761	65·1328	·0328	·76397
	30	·361	·633	·445	·158	280·8436	·0326	·36312
June	9	·382	·654	·466	·554	136·5543	·0324	·96226
	19	·404	·674	·486	·951	352·2650	−·0322	·56140
	29	·426	·695	·507	·347	207·9758	·0320	·16054

Fourth Satellite.

	Arguments.						
1895.	β_4	γ_4	δ_4	ϵ_4	ζ_4	η_4	θ_4
Aug. 24	·352	·903	·581	·168	·265	·159	·948
Sept. 3	·150	·502	·175	·362	·464	·376	·148
13	·949	·101	·770	·555	·663	·593	·347
23	·747	·700	·365	·749	·863	·809	·547
Oct. 3	·546	·299	·959	·943	·062	·026	·746
13	·344	·898	·554	·137	·261	·243	·946
23	·143	·497	·148	·330	·461	·460	·145
Nov. 2	·941	·096	·743	·524	·660	·677	·345
12	·740	·695	·338	·719	·860	·893	·544
22	·538	·294	·932	·912	·059	·110	·744
Dec. 2	·337	·893	·527	·106	·258	·327	·943
12	·135	·492	·122	·299	·458	·544	·143
22	·933	·091	·716	·493	·657	·760	·342
1896.							
Jan. 1	·732	·690	·311	·686	·856	·977	·542
11	·531	·289	·906	·881	·056	·194	·742
21	·329	·888	·500	·074	·255	·411	·941
31	·128	·487	·095	·268	·455	·627	·141
Feb. 10	·926	·086	·689	·462	·654	·844	·340
20	·725	·685	·284	·656	·853	·061	·540
Mar. 1	·524	·284	·879	·850	·053	·278	·739
11	·322	·883	·473	·043	·252	·495	·939
21	·121	·482	·068	·237	·451	·711	·138
31	·919	·081	·663	·431	·651	·928	·338
Apr. 10	·718	·680	·257	·625	·850	·145	·537
20	·516	·279	·852	·818	·050	·362	·737
30	·315	·878	·446	·012	·249	·578	·936
May 10	·113	·477	·041	·206	·448	·795	·136
20	·912	·076	·636	·400	·648	·012	·335
30	·710	·675	·230	·594	·847	·229	·535
June 9	·509	·274	·825	·787	·046	·445	·734
19	·307	·873	·420	·981	·246	·662	·934
29	·106	·472	·609	·175	·445	·879	·133

Errata in Mr. Innes's Paper.

Page 313, 2nd last line, *after* stars *add* near.
„ 314, 9th line, *delete* The brightest star in finder S. of η Pavonis.
„ 314, 19th line, *delete* full stop after "it."
„ 315, 12th line, *for* 71″ *read* > 1″.

Errata in Mr. Knobel's Paper.

Page 434, *for* Batina *read* Batiya.
„ 437, *delete* last sentence of note to Star 61.

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American Academy of Arts and Sciences, Proceedings, vol. xx., xxi., 8vo. *Boston*, 1893–94 — The Academy.

American Journal of Mathematics, vol. xvi. 3–xvii. 2, 4to. *Baltimore*, 1894–95 — The Editors.

American Journal of Science, series III., Nos. 283–294, 8vo. *New Haven*, 1894–95 — ———

Amsterdam, Koninklijke Akademie van Wetenschappen, Jaarboek, 1893, 8vo. *Amsterdam*, 1893 — The Academy.

—— Verhandelingen, 1ste sectie, Deel ii., Nos. 1–6, 8, 8vo. *Amsterdam*, 1893–94 — ———

—— Verslagen der Zittingen, 1893–94, 8vo. *Amsterdam*, 1894 — ———

Angelitti, F., Determinazioni assolute della declinazione magnetica nel R. Osservatorio di Capodimonte eseguite nell' anno 1891, 4to. *Napoli*, 1893 — The Author.

—— Variazioni della declinazione magnetica osservate nella R. Specola di Capodimonte nell' anno 1891, 4to. *Napoli*, 1894 — ———

—— Distanze zenitale circummeridiane del Sole osservate nell' anno 1821 dall' astronomo Carlo Brioschi, 4to. *Napoli*, 1894 — ———

The Author. Armani, P., Francesco Denza, Cenni necrologici, 8vo. *Roma*, 1894

The Association. Association Géodésique Internationale, Comptes rendus des séances de la Commission Permanente réunie à Genève, 1893, 4to. *Berlin und Neuchatel*, 1894

The Editor. Astronomical Journal, Nos. 319–346, 4to. *Boston*, 1894–95

The Society. Astronomical Society of the Pacific, Publications, Nos. 36–41. 8vo. *San Francisco*, 1894–95

The Editor. Astronomie, L', Revue mensuelle d'astronomie populaire, de météorologie, et de physique du globe, publiée par C. Flammarion, année xiii. 7–12. *Paris*, 1894

——— Astronomische Mittheilungen, No. lxxxiv., herausgegeben von A. Wolfer, 8vo. *Zürich*, 1894

——— Astronomische Nachrichten, Nos. 3235–3290, 4to. *Kiel*, 1894–95

The Editors. Astronomy and Astro-Physics, Nos. 126–129, 8vo. *Northfield, Minn.*, 1894

——— Astro-Physical Journal, vol. i. 1–5, 8vo. *Chicago*, 1895

The Editor. Athenæum, The, Nos. 3476–3528, 4to. *London*, 1894–95

The Association. Australasian Association for the Advancement of Science, Report of the fifth meeting, held at Adelaide, South Australia, 1893, 8vo. *Adelaide and Sydney*, 1894

The Author. Barnard, E. E., Micrometrical observations of the fifth satellite of *Jupiter* during the opposition of 1893, with measures of diameters of *Jupiter*, 1892–94, 4to. *Boston*, 1894

——— —— Photographs of Gale's comet, 8vo. *Northfield, Minn.*, 1894

——— —— Photograph of a remarkable comet; photograph of M. 8 and the Trifid Nebula; the great photographic nebula of Orion encircling the belt and θ Nebula; the form of the disc of the III. satellite, and phenomena of the occultation of a satellite of *Jupiter*, 8vo. *Northfield, Minn.*, 1894

——— —— —— The great red spot, and other markings on *Jupiter*; on the exterior nebulosities of the *Pleiades*, 8vo. *Northfield, Minn.*, 1894

——— —— Photographs of Swift's Nebula in *Monoceros*, N.G.C. 2237, 8vo. *Northfield, Minn.*, 1894

Barnard, E. E., Micrometrical observations of Nova (T) Aurigæ, made with the 36-inch equatorial of the Lick Observatory, 4to. *Kiel*, 1894 — The Author.

—— Observations of the transits of *Mercury*, 1891 May 9 and 1894 Nov. 9–10, 4to. *Boston*, 1895 — ——

—— Photographs of the Milky Way, 8vo. *Chicago*, 1895 — ——

Batavia, Koninklijke Natuurkundige Vereeniging, Natuurkundig Tijdschrift voor Nederlandsch-Indië, Deel liii., 8vo. *Batavia*, 1893 — The Society.

Batavia, Magnetical and Meteorological Observatory. Observations, vol. xvi., 1893, 4to. *Batavia*, 1894 — The Observatory.

—— Rainfall in the East Indian Archipelago, 15th year, 1893, 8vo. *Batavia*, 1894 — ——

Belfast Natural History and Philosophical Society, Report and Proceedings for the session 1893-94, 8vo. *Belfast*, 1895 — The Society.

Berlin, Astronomisches Jahrbuch für 1897, mit Angaben für die Oppositionen der Planeten $(1 - \overbrace{368}$, für 1895, 8vo. *Berlin*, 1895 — The Observatory, Berlin.

Berlin, Centralbureau der Internationalen Erdmessung, Verhandlungen der vom 5 bis 12 September 1894 in Innsbrück abgehaltenen Conferenz der Permanenten Commission, 4to. *Berlin*, 1895 — The Bureau.

Berlin, Königlich-preussische Akademie der Wissenschaften, Abhandlungen aus dem Jahre 1893, 4to. *Berlin*, 1893 — The Academy.

—— Sitzungsberichte, 1894, i—1895, xx., 8vo. *Berlin*, 1894–95 — ——

Berlin, Physikalische Gesellschaft, Die Fortschritte der Physik im Jahre 1888, Abth. iii., 8vo. *Braunschweig*, 1894 — The Society.

Bologna, Reale Accademia delle Scienze, Memorie, serie V. tomo iii. Memorie della sezione delle scienze fisiche e mathematiche, 4to. *Bologna*, 1893 — The Academy.

Bombay Branch of the Royal Asiatic Society, Journal, vol. xviii., Nos. 49–50, 8vo. *Bombay*, 1894 — The Society.

Bombay, Government Observatory, Magnetical and Meteorological Observations, made in the year 1893, under the direction of C. Chambers, fol. *Bombay*, 1894 — The Observatory.

—— Brief sketch of the Meteorology of the Bombay Presidency in 1893-94, fol. *Bombay*, 1894 — ——

The Observatory. Bordeaux, Observatoire, Annales, publiées par G. Rayet, tome v., 4to. *Paris et Bordeaux*, 1894

The Society. Bordeaux, Société des Sciences physiques et naturelles, Mémoires, série IV., tome iii. 2 ; tome iv. 1–2, 8vo. *Paris and Bordeaux*, 1893–94

——— —— Appendice au tome iv., Observations pluviométriques et thermométriques faites dans le département de la Gironde, 1892–93, par G. Rayet, 8vo. *Bordeaux*, 1893

The Author. Breach, E., Dauntless Astronomy, 16mo. *Portsmouth*, 1894

——— Brédikhine, Th., Mouvement des substances émises par les Comètes, 1893 ii. et 1893 iv., 4to. *St.-Pétersbourg*, 1895

——— —— Sur les Perséides observées en Russie en 1894, 4to. *St.-Pétersbourg*, 1895

The Association. British Association for the Advancement of Science, Report of the sixty-fourth meeting, held at Oxford, 1894, 8vo. *London*, 1895

——— —— List of Officers, Council, and Members, 1894, 8vo. *London*, 1894

——— British Astronomical Association, Journal, vol. iv. No. 7—v, No. 7, 8vo.

——— —— Memoirs, vol. ii. parts 3–6, 8vo. *London*, 1894–95

The Observatory. Brussels, Observatoire Royal de Belgique, Annuaire, 1895 (62e année), 16mo. *Bruxelles*, 1895

The Society. Brussels, Société Belge d'Astronomie, Statuts, 8vo. *Bruxelles*, 1895

The Institute. Buda-Pest, Königl. Ung. Central-Anstalt für Meteorologie und Erdmagnetismus, Band xxi., 1891, 4to. *Buda-Pest*, 1894

The Office. Buenos Aires, Oficina Meteorológica Argentina, Anales, por su director G. G. Davis, tomo ix., Clima de Córdoba, part i.–ii., 4to. *Buenos Aires*, 1893–94

The Editors. Bulletin des Sciences Mathématiques, série II., tome xviii. 4–xix. 6, 8vo. *Paris*, 1894–95

The Author. Burnham, S. W., The orbit of 9 *Argûs* (β 101), 8vo. *Northfield, Minn.*, 1893

——— —— Life and work of E. E. Barnard, 8vo. *Northfield, Minn.*, 1894

——— —— How to find the orbit of a double star by a graphical method, 8vo. *Northfield, Minn.*, 1894

Burnham, S. W., The variable proper motion of *Procyon* *Northfield, Minn.*, 1894 — The Author.

—— Double-star observations made with the thirty-six inch and twelve-inch refractors of the Lick Observatory, 1888–92, 4to. *Sacramento*, 1894 — ——

Calcutta, Asiatic Society of Bengal, Journal, part ii., vol. lxii., 4—lxiv. 1, 8vo. *Calcutta*, 1894–95 — The Society.

—— Proceedings, 1893, 10—1895, 3, 8vo. *Calcutta*, 1894–95 — ——

—— Annual address by the President, 1894, 8vo. *Calcutta*, 1894 — ——

Cambridge Philosophical Society, Proceedings, vol. viii., parts 3–4, 8vo. *Cambridge*, 1894–95 — ——

Camera Club, Journal, Nos. 98–109, 4to. *London*, 1894–95 — The Club.

Canada, Dominion of, Report of the meteorological service for the year ending Dec. 31, 1889, by C. Carpmael, 8vo. *Ottawa*, 1893 — The Canadian Government.

Canada, Royal Society, Proceedings and Transactions for the year 1893, vol. xi., 4to. *Ottawa*, 1894 — The Society.

Cape of Good Hope, Royal Observatory, Heliometer observations for determination of stellar parallax, by David Gill, 8vo. *London*, 1893 — The Observatory.

—— Report of H.M. Astronomer for 1879–93, 4to. *London*, 1893–94 — ——

Cape Town, South African Philosophical Society, Transactions, vol. v., part 2, 8vo. *Cape Town*, 1893 — The Society.

Cardiff, Astronomical Society of Wales, Journal, vol. i., Nos. 1–5, 16mo. *Cardiff*, 1895 — ——

Cayley, A., The collected mathematical papers of, vol. vii., 4to. *Cambridge*, 1894 — The Author.

Charkow, Universitäts-Sternwarte, Publication, Heft 2, 3, 8vo. *Charkow*, 1893–95 — The Observatory.

Clerk of the Weather, the, Edited by H. Clements, vol. i., No. 1, 4to. *London*, 1895 — The Editor.

Contarino, Fr., Sulla determinazione della latitudine col metodo di Döllen, 4to. *Kiel*, 1894 — The Author.

Copenhagen, Kongelige Danske Videnskabernes Selskab, Oversigt over det Forhandlinger, 1893, iii., 1894, i., 2, 8vo. *Kjöbenhavn*, 1893–94 — The Society.

The Observatory. Cordoba, Observatorio Nacional Argentino, Resultados, vol. xvii.; Zonas de exploracion brillantez y posicion de todas las estrellas fijas hasta la décima magnitud, entre 32 y 42 grados de declinacion sud, con un atlas, 4to. and fol. *Buenos Aires*, 1894

The College. Cork, Queen's College, Calendar, 1894–95, 8vo. *Cork*, 1894

The Author. Cornu, A., La Synchronisation Électromagnétique, 4to. *Paris*, 1894

The Academy. Cracow, Académie des Sciences, Bulletin International, Comptes rendus des séances de l'année 1894, v.–1895, iv., 8vo. *Cracovie*, 1894-95

The Author. Davis, H. S., The parallax of η Cassiopeiæ deduced from the Rutherfurd photographic measures (Contributions from the Observatory of Columbia College, New York, No. 6), 8vo. *New York*, 1895

The School. Delft, École Polytechnique, Annales, tome viii. 1, 2, 4to. *Leide*, 1894

The Author. Deslandres, H., The Solar faculæ, 8vo. *London*, 1883

——— —— Loi de répartition des raies et des bandes, commune à plusieurs spectres de bandes : Analogie avec la loi de succession des sons d'un corps solide, 4to. *Paris*, 1887

——— —— Spectre de bandes ultra-violet des composés hydrogénés et oxygénés du carbone, 4to. *Paris*, 1888

——— —— Spectres de bandes ultra-violets des métalloides avec une faible dispersion, 4to. *Paris*, 1888

——— —— Organisation des recherches spectroscopiques avec le grand télescope de l'Observatoire de Paris, 4to. *Paris*, 1890

——— —— Propriété fondamentale commune aux deux classes de spectres, 4to. *Paris*, 1890

——— —— Recherches sur le mouvement radial des astres avec le sidérostat de l'Observatoire de Paris, 4to. *Paris*, 1891

——— —— Méthode nouvelle pour la recherche des bandes faibles dans les spectres de bandes. Application au spectre des hydrocarbures, 4to. *Paris*, 1891

——— —— Sur les spectres de bandes du carbone dans l'arc électrique, 8vo. *Paris*, 1891

——— —— Recherches nouvelles sur l'atmosphère solaire (2 memoirs), 4to. *Paris*, 1891–9

Deslandres, H., Sur une protubérance remarquable, 4to. *Paris*, 1892 — The Author.

—— Résultats nouveaux sur l'hydrogène obtenus par l'étude spectrale du Soleil; rapprochements avec l'étoile nouvelle du Cocher, 4to. *Paris*, 1892 — ——

—— Transformation du grand télescope de l'Observatoire de Paris pour l'étude des vitesses radiales des astres: Résultats obtenus, 4to. *Paris*, 1892 — ——

—— Spectre du pôle négatif de l'azote: loi générale de répartition des raies dans les spectres de bandes, 4to. *Paris*, 1892 — ——

—— Contribution à la recherche de la couronne solaire en dehors des éclipses totales (2 memoirs), 4to. *Paris*, 1893 — ——

—— Sur l'observation de l'éclipse totale du soleil du 16 avril, faite à Foundiongue (Sénégal), 4to. *Paris*, 1893 — ——

—— Recherches photographiques sur les flammes de l'atmosphère solaire, 8vo. *Paris*, 1893 — ——

—— Sur l'enregistrement des éléments variables du soleil, 4to. *Paris*, 1893 — ——

—— Sur la recherche de la partie de l'atmosphère coronale du soleil projetée sur le disque, 4to. *Paris*, 1893 — ——

—— Appareils enregistreurs de l'atmosphère solaire, 8vo. *Paris*, 1894 — ——

—— Sur la photographie de la chromosphère du soleil, 4to. *Paris*, 1894 — ——

—— Sur la chromosphère du soleil; réponse à M. Hale, 4to. *Paris*, 1894 — ——

—— Images spéciales du soleil données par les simples qui correspondent aux raies noires du spectre solaire, 4to. *Paris*, 1894. — ——

—— Recherches sur les mouvements de l'atmosphère solaire, 4to. *Paris*, 1894 — ——

—— Étude des gaz et vapeurs du Soleil, 8vo. *Paris*, 1894 — ——

—— Sur l'origine électrique de la chromosphère solaire, 8vo. *Paris*, 1894 — ——

—— Sur l'enregistrement de la chromosphère et de la photosphère du Soleil par la méthode des sections successives, 8vo. *Paris*, 1894 — ——

Dijon, Académie des Sciences, Arts et Belles-lettres, Mémoires, série IV., tome iv., Années 1893–94, 8vo. *Dijon*, 1894 — The Academy.

Astronomical Society of Russia. Döllen, W., Éphémérides des étoiles pour la détermination de l'heure et de l'azimut au moyen d'un instrument des passages portatif établi dans le plan vertical de la polaire pour 1895, 8vo. *St.-Pétersbourg*, 1895

The Author. Donner, Anders, Détermination des constantes nécessaires pour la réduction les clichés pris à Helsingfors pour la construction du Catalogue photographique jusqu'à la onzième grandeur, 4to. *Helsingsfors*, 1894

——— Douglass, A. E., A cloud-like spot on the terminator of *Mars*, 8vo. *Chicago*, 1895

——— Dreyer, J. L. E., Micrometrical Observations of Nebulæ made at the Armagh Observatory, 4to. *Dublin*, 1894

The Academy. Dublin, Royal Irish Academy, Proceedings, 3rd series, vol. iii. 2, 3, 8vo. *Dublin*, 1894

——— ——— Transactions, vol. xxx. 11, 12, 4to. *Dublin*, 1894

The Author. Easton, C., Sur la distribution apparente des étoiles dans une partie de la Voie lactée, 4to. *Kiel*, 1894

Royal Observatory Edinburgh. Edinburgh Circular, No. 43.

Edinburgh Review, The, No. 370, 8vo. *London*, 1894

The Publishers (G. Phillip & Son). Elger, T. G., The moon ; a full description and map of its principal physical features, 8vo. *London*, 1895

The Editor. English Mechanic, The, and World of Science, Nos. 1525–1577, fol. *London*, 1894–95

The Author. Fényi, J., On a very large protuberance observed Dec. 24, 1894, 8vo. *Chicago*, 1895

The Hydrographer Field, A. M., Commander, Longitude of Malacca, Straits Settlements, fol. *London*, 1894

The Author. Field, Osgood, The Fields of Sowerby, near Halifax, England, and of Flushing, New York, 4to. *London*, 1895

The Editor. Flammarion, C., Annuaire Astronomique et météorologique pour 1895, 8vo. *Paris*, 1894

The Author. Forbes, George, On Comets and Ultra-Neptunian planets, 4to. *Edinburgh*, 1880

——— Franz, J., Darlegung der Ephemeridenrechnung von Mösting A, 4to. *Kiel*, 1894

——— ——— Der Einfluss der Phase auf die scheinbare Lage von Mösting A, 4to. *Kiel*, 1894

Franz, J., Königsberger Meridianbeobachtungen von Mösting A, 4to. *Kiel*, 1894 — The Author.

—— Ephemeride zur Beobachtung des Mondkraters Mösting A, 8vo. *Königsberg*, 1894 — ——

Gaillot, A., Addition à la théorie du mouvement par Le Verrier, et rectification des tables, 4to. *Paris*, 1895 — ——

Galle, J. G., Verzeichniss der Elemente der bisher berechneten Cometenbahnen, nebst Anmerkungen und Literatur-Nachweisen ; neu bearbeitet, ergänzt, und fortgesetzt bis zum Jahre 1894, 8vo. *Leipzig*, 1894 — ——

—— Ueber die Bahn des am 4. December 1893 vornehmlich in Schlesien beobachteten hellen Meteors, 8vo. *Breslau*, 1894 — — —

Galway, Queen's College, Calendar for 1894–95, 8vo. *Dublin*, 1895 — The College.

Gautier, Raoul, Le service chronométrique à l'Observatoire de Genève, 8vo. *Genève*, 1894 — The Author.

Geneva, Société de Physique et d'Histoire naturelle, Mémoires, tome xxxii., partie 1, 4to. *Genève*, 1894–95 — The Society.

—— Société des Arts, Concours International de Réglage pour Chronomètres in 1896, 8vo. *Genève*, 1894 — ——

Geological Society, Quarterly Journal, Nos. 199–202, 8vo. *London*, 1894–95 — ——

Giberne, Agnes, Radiant Suns ; a sequel to "Sun, Moon and Stars" ; with a preface by Mrs. Huggins, 8vo. *London*, 1895 — The Author.

Ginzel, F. K., Über einen Versuch, das Alter der Vedischen Schriften aus historischen Sonnenfinsternissen zu bestimmen, 8vo. *Prag*, 1894 — W. T. Lynn.

Glasenapp, S. de, Observations Astronomiques, faites à Abastouman, 8vo. *St.-Pétersburg*, 1894 — The Author.

Glasgow, Mitchell Library, Twelfth General Report, 8vo. *Glasgow*, 1895 — The Library.

Gore, J. E., The worlds of space, 8vo. *London*, 1894 — M. C. Sharp.

Gothard, E. von, Erfahrungen auf dem Gebiete der Himmelsphotographie, 8vo. *Halle*, 1894 — E. von Gothard.

Göttingen, Königliche Gesellschaft der Wissenschaften, Nachrichten, Mathematisch-physikalische Klasse, 1894, 1–1895, 1, 8vo. *Göttingen*, 1894–95 — The Society.

The Observatory. Göttingen, Königliche Sternwarte, Astronomische Mittheilungen, herausgegeben von W. Schur, Theil iii., L. Ambronn, Triangulation der Plejadengruppe, 4to. *Göttingen*, 1894

The Author. Grandi, Luigi, Lettera aperta agli astronomi, 4to. 1894

The Observatory. Greenwich, Royal Observatory, Astronomical and Magnetical and Meteorological observations made in the year 1891, under the direction of W. H. M. Christie, 4to. *London*, 1893

——— —— Astronomical Results, 1891, 4to. *London*, 1893

——— —— Magnetical and Meteorological Results, 1891, 4to. *London*, 1893

——— —— Spectroscopic and photographic results, 1891, 4to. *London*, 1893

——— —— Five-year catalogue of 258 fundamental stars for 1890, 4to. *London*, 1893

——— —— Rates of chronometers and deck watches, 1893–94, 4to, *London*, 1894

——— —— Assumed mean right ascensions of clock stars and circumpolar stars for 1895·0, 4to. *London*, 1894

——— —— Report of the Astronomer Royal to the Board of Visitors, 1894–95, 4to. *London*, 1895

The Author. Grubb, Sir H., The development of the astronomical telescope, 8vo. *London*, 1894

——— Gruson, Hermann, Im Reiche des Lichtes : Sonnen, Zodiakallichte, Kometen : Dämmerungslicht-Pyramiden nach den ältesten ägyptischen Quellen, 8vo. *Braunschweig*, 1895

Berne University. Gubler, Ed., Verwandlung einer hypergeometrischen Reihe im Anschluss an das Integral $\int_0^\infty {}^a\mathrm{J}(x)e^{-bx}x^{e-1}dx$. Inaugural Dissertation, 8vo. *Uster*, 1894

The Author. Guillaume, J., Observations du soleil faites à l'équatorial Brunner de l'Observatoire de Lyon, 8vo.

——— Gyldén, H., Zur Transformation der periodischen Aggregate, 4to. *St. Petersburg*, 1894

The Museum. Haarlem, Musée Teyler, Archives, série II., vol. iv., 3, 8vo. *Haarlem*, 1894

The Author. Hale, G. E., The Astrophysical Journal, 8vo. *Northfield, Minn.*, 1894

Hale, G. E., On some attempts to photograph the solar corona without an eclipse, 8vo. *Northfield, Minn.* — The Author.

Hamburg, Sternwarte, Bericht des Direktors, 1894, 4to. *Hamburg*, 1894 — The Observatory.

—— Mittheilungen; No. 1, G. Rümker, Positionsbestimmungen von Nebelflecken und Sternhaufen; No. 2, C. Stechert, Bahnbestimmung des Planeten (258) Tyche, 4to. *Hamburg*, 1895 — ——

Harvard College Astronomical Observatory, Annals, vol. xxii., part i., Investigations in Astronomical Photography, by W. H. Pickering, 4to. *Cambridge, Mass.*, 1895 — ——

—— Annals, vol. xxxv., Journal of the Zone Observations, 4to. *Waterville, Me.*, 1894 — ——

—— Annals, vol. xl., part iii.; vol. xli., No. 1, Meteorological Observations, 4to. *Cambridge, Mass.*, 1894 — ——

—— Forty-ninth Annual Report of the Director, 1894, 8vo. *Cambridge, Mass.*, 1894 — ——

Hasselberg, B., Ueber das Linienspectrum des Sauerstoffs, 8vo. *Leipzig*, 1894 — The Author.

—— Sur les observations spectroscopiques des nébuleuses faites à Mount Hamilton à l'aide du grand réfracteur de Lick, par J. E. Keeler, 4to. *Roma*, 1895 — ——

Helsingfors, Finska Vetenskaps-Societet, Öfversigt af Förhandlingar, xxxv., 1892–93, 8vo. *Helsingfors*, 1893 — The Society.

—— —— Acta Societatis Scientiarum Fennicæ, tomus xix., 4to. *Helsingfors*, 1893 — ——

—— —— Bidrag till Kännedom Finlands Natur och Folk, 52, 53, 8vo. *Helsingfors*, 1893 — ——

Helsingfors, Institut Météorologique Central, observations météorologiques, 1881–88, 4to. *Kuopio*, 1893–94 — The Institute.

—— Observations, vols. vi.–viii., xi. Observations météorologiques faites à Helsingfors, 1887–89, 1892, 4to. *Helsingfors*, 1893 — ——

Helsingfors, Société de Géographie de Finlande, Fennia, 9, 11, 8vo. *Helsingfors*, 1894 — The Society.

Herény, Physikalisches Observatorium, Meteorologische Beobachtungen im Jahre 1891, herausgegeben von E. von Gothard, 4to. *Budapest*, 1894 — E. von Gothard.

The Author. Hill, G. W., Literal expression for the motion of the Moon's perigee, 4to. 1894

The Editor. Himmel und Erde ; illustrierte naturwissenschaftliche Monatsschrift, herausgegeben von der Gesellschaft Urania ; Jahrgang vi. 10–vii. 9, 8vo. *Berlin*, 1894–95

M. C. Sharp. Hind, J. R., The illustrated London Astronomy, 8vo. *London*, 1853

The Author. Holden, E. S., A brief account of the Lick Observatory, 8vo. *Sacramento*, 1895

The Observatory. Hong-Kong Observatory, Observations and researches made in the year 1893, by W. Doberck, fol. *Hong-Kong*, 1894

British Horological Institute. Horological Journal, The, a monthly paper for watch and chronometer makers, Nos. 431–442, 8vo. *London*, 1894–95

The Author. Huggins, Margaret, L., The Astrolabe, 8vo. *Northfield, Minn.*, 1894

The Society. Hull, Literary and Philosophical Society, Annual Report of the Council and Transactions, 1894–95, 8vo. *Hull*, 1895

H. M.'s Government in India. India, Great Trigonometrical Survey, Catalogue of stars for the epoch Jan. 1, 1892, 4to. *Dehra Dûn*, 1893

——— India, Survey Department, General Report on the operations during 1892–93, fol. *Calcutta*, 1894

The Editor. Indian Engineering, vol. xv. 20—xvii. 20, fol. *Calcutta*, 1894–95

The Author. Inwards, R., On some phenomena of the upper air, 8vo. *London*, 1894

Lieut. C. W. Baillie. Japanese astronomical works (four works).

The Author. Jenkins, B. G., Tellustria ; a method for determining astronomically the variations in the temperature and pressure of the atmosphere, 8vo. *London*, 1894

——— Johnson, R. C., The new astronomy ; an account of astrophotography, 8vo. *Liverpool*, 1894

——— Kammermann, A., Résumé météorologique de l'année 1893 pour Genève et le Grand Saint-Bernard, 8vo. *Genève*, 1894

The University. Kasan, Imperial University, Scientific Memoirs, 1894, No. 3–1895, No. 4 [in Russian], 8vo. *Kasan*, 1894–95

——— ——— Observations of variable stars of the Algol type, 1891–92 [in Russian], 8vo. *Kasan*, 1893

Kasan, Observatoire Astronomique de l'Université Impériale. Observations with the transit instrument in the prime vertical, and Catalogue of the declinations of 202 stars, 4to. *Kasan*, 1893 — The Observatory.

Kasan, Observatoire Astronomique de l'Université Impériale, Resultate der Beobachtungen in Kasan betreffend die Veränderlichkeit der Polhöhe. I. Beobachtungsreihe 30 April 1892—12 Juli 1893, von A. M. Kowalski, 4to. *Kasan*, 1894 — ———

—— Observations of the Perseids [in Russian], 8vo. *Kasan*, 1894 — ———

—— Ephemerides of the Sun and Moon for the year 1894, 8vo. *Kasan*, 1893 — ———

Keeler, J. E., On the spectra of the *Orion* nebula, and the *Orion* stars, 8vo. *Northfield, Minn.*, 1894 — The Author.

—— Spectroscopic observations of nebulæ made at Mount Hamilton, California, with the 36-inch refractor of the Lick Observatory. *Sacramento*, 1894 — — —

Kew Observatory, Report of the Incorporated Kew Committee for the year 1894, 8vo. *London*, 1894 — The Committee.

Kostinsky, S., Sur la parallaxe de β *Cassiopeiæ*, 4to. *St.-Pétersbourg*, 1894 — The Author.

Von Kuffner'sche Sternwarte, Publicationen, herausgegeben von L. de Ball, Band iii., 4to. *Wien*, 1894 — The Observatory.

Langley, S. P., Nouvelles recherches sur la région infra-rouge du spectre solaire, 4to. *Paris*, 1894 — The Author.

Laplace, P. S. de, Œuvres complètes, tome x., 4to. *Paris*, 1894 — The Academy of Sciences, Paris.

Larlein, Henry, Elliptical orbits ; their distinctive mechanical characteristics and their possible origin, 8vo. *London*, 1895 — The Author.

Leiden, Verslag van den staat der Sterrenwacht te Leiden, 1893–94. H. G. van de Sande Bakhuyzen, 8vo. *Leide*, 1894 — The Observatory.

Leipzig, Astronomische Gesellschaft, Vierteljahrsschrift, Jahrgang 29, Heft. 1–3, 8vo. *Leipzig*, 1894 — The Society.

—— Catalog, Erste Abtheilung, 6tes Stück ; Zone +40° bis +50°. Beobachtet auf der Sternwarte zu Bonn, 4to *Leipzig*, 1894 — ———

The Society. Leipzig, Königlich Sächsische Gesellschaft der Wissenschaften, Abhandlungen der mathematisch-physischen Classe, Band xxi. 2–xxii. 1., 8vo. *Leipzig*, 1894–95

——— —— —— Berichte über die Verhandlungen, 1894, ii.—1895, i., 8vo. *Leipzig*, 1894–95

The Observatory. Lick Observatory of the University of California, Publications, vol. ii., double star measures, by S. W. Burnham; vol. iii. selenographical studies, by L. Weinek; spectroscopic observations of nebulæ, by J. E. Keeler, &c., 4to. *Sacramento*, 1894

The Academy. Lisbon, Academia Real das Sciencias; Jornal de sciencias mathematicas, physicas e naturaes, Nos. xlvi.–xlviii., 1887–88, 8vo. *Lisboa*, 1887–88

——— —— —— Segunda serie, tom. i.—iii., 8vo. *Lisboa*, 1890–95

——— —— Memorias, Classe de sciencias mathematicas, physicas e naturaes, Nova serie, tomo vi., Parte II., 4to. *Lisboa*, 1887

——— —— Sessão publico em 17 de Dezembro de 1893, 8vo. *Lisboa*, 1893

——— —— Elogio historico de S. M. el Rei d. Luiz i., 4to. *Lisboa*, 1890

——— —— —— A. H. de Carvalho e Aranjo, 4to. *Lisboa*, 1890

——— —— —— A. V. Lourenço, 4to. *Lisboa*, 1893

——— —— Machado, V., A Electricidade; estudo de algumas das suas principaes applicações, 8vo. *Lisboa*, 1887

——— —— —— As applicações medicas e cirurgicas da electricidade, 8vo. *Lisboa*, 1895

——— —— Machado, V. e A., Chimica Geral e Analyse Chimica, 2 vols., 8vo. *Lisboa*, 1892

——— —— Chagas, M. Pinheiro, Os descobrimentos Portuguezes e os de Colombo: tentativa de coordenação historica, 8vo. *Lisboa*, 1892

——— —— Coelho, J. M., Latino, Compendio de mineralogia morphologia mineral, 8vo. *Lisboa*, 1892

——— —— Horta, F. P., Estudo elementar dos determinantes; seguido de uma parte complimentar relativa, principalmente, aos determinantes funccionaes, 8vo. *Lisboa*, 1889

The Observatory. Liverpool Observatory, Bidston, Extracts from the report of the Director, and meteorological results deduced from observations taken 1892 and 1893, 8vo. *Liverpool*, 1894

Lorentzen, G., Ueber die Untersuchung der Scalen eines Heliometers, 4to. *Kiel*, 1894. — The Author.

Lund Observatoire, Observations des étoiles de la Zone, entre 35° et 40° de déclinaison boréale, réduites à l'équinoxe moyen de 1875·0, par N. C. Dunér et F. Engström, tome ii., Nos. 4, 5, 4to. *Lund*, 1894–95 — The Observatory.

Lynn, W. T., Remarkable Comets, 3rd edition, 8vo. *London*, 1895 — The Author.

Madras, Government Observatory, Results of observations of the Fixed Stars made with the meridian circle in the years 1880–87, under the direction of N. R. Pogson, by C. Michie Smith, vols. vii., viii., 4to. *Madras*, 1894 — The Observatory.

Madrid, Academia de Ciencias exactas, físicas y naturales, Anuario, 1895, 16mo. *Madrid*, 1895 — The Academy.

Madrid, Observatorio, Observaciones meteorológicas, 1892–93, 8vo. *Madrid*, 1894. — The Observatory.

Manchester Literary and Philosophical Society, Memoirs and Proceedings, series IV., vol. viii. 3—ix. 2, 8vo. *Manchester*, 1894–95 — The Society.

Manchester Public Free Libraries, 42nd Annual Report, 8vo. *Manchester*, 1894 — The Library.

Manila, Observatorio meteorológico, observaciones, 1892, 8–1894, 5; y Appendice al año 1892, fol. *Manila*, 1894 — The Observatory.

—— La Seismologia en Filipinas, por M. Saderra Masó, 4to. *Manila*, 1895 — ——

Mauritius, Royal Alfred Observatory, Meteorological Observations, 1893, fol. *Mauritius*, 1894 — ——

Melbourne Observatory, Monthly record of results of observations in meteorology, terrestrial magnetism, &c., &c., taken under the superintendence of R. L. J. Ellery, 1893–4, 8vo. *Melbourne*, 1893–94 — ——

Meteorological Office, Meteorological observations at stations of the second order for the year 1890, 4to. *London*, 1894 — The Office.

—— Weekly Weather Report, vol. xi. 23–xii. 23, 4to. *London*, 1894–95 — ——

Montpellier, Académie des sciences et lettres, Mémoires de la section des sciences, série II., tome i. 3, 4, tome ii. 1, 8vo. *Montpellier*, 1893–94 — The Academy.

The Society. Moscow, Société Impériale des Naturalistes, Bulletin, année 1894, Nos. 1–4, 8vo. *Moscou*, 1894–95

The Academy. Munich, Königlich-Bayerische Akademie der Wissenschaften, Sitzungsberichte der mathematisch-physikalischen Classe, 1894, ii.–1895, i., 8vo. *München*, 1894–95

——— Naples, Reale Accademia delle scienze fisiche e matematiche, Atti, serie II., vol. vi., 4to. *Napoli*, 1894

——— —— Rendiconto, serie II., vol. viii. 3–serie III., vol. i. 4, 4to. *Napoli*, 1894–95

The Observatory. Naples, Osservatorio di Capodimonte, Osservazioni meteorologiche, 1893, 4to. *Napoli*, 1894

——— —— Riassunti decadici e mensuali delle osservazioni meteoriche, fatte nell' anno 1892, nota di F. Brioschi, 4to. *Napoli*, 1893

——— Natal Observatory, Annual Report of the Superintendent, 1893–94, fol. *Pietermaritzburg*, 1894

The Editor. Naturwissenschaftliche Rundschau, Jahrgang ix. 24–x. 24, 4to. *Braunschweig*, 1894–95

Lords Commrs. of Admiralty. Nautical Almanac and astronomical ephemeris for the year 1898, 8vo. *London*, 1895

——— —— Ditto, part 1 (containing such portions as are essential for navigation), 8vo. *London*, 1895

Nautical Almanac Office. —— Circular No. 16, Local particulars of the total eclipse of the Sun, 1898, January 21–22, 8vo. *London*, 1895

American Ephemeris Office. Newcomb, Simon, The elements of the four inner planets and the fundamental constants of astronomy. (Supplement to the American Ephemeris for 1897), 8vo. *Washington*, 1895

The Society. New York Mathematical Society, Bulletin, vol. iii. 9–series II., vol. i., 8, 8vo. *New York*, 1894–95

The Author. Nobile, A., Risultate di talune osservazioni di distanze zenitali, 4to. *Napoli*, 1894

——— —— Studio iniziale del collimatore del cerchio meridiano Reichembach-Heurtaux, 4to. *Napoli*, 1894

——— —— Saggio di determinazione diretta della costante di una linea geodetica nell' ellissoide di rivoluzione schiacciato date le coordinate di due punti, 4to. *Napoli*, 1894

Nobile, A., Ascensioni Rette determinate simultaneamente a Capodimonte ed a Cordoba (Repubblica Argentina), 4to. *Napoli*, 1894 — The Author.

Observatory, The, a monthly review of Astronomy, Nos. 216–228, 8vo. *London*, 1894–95 — The Editors.

O-Gyalla, Astrophysikalisches Observatorium, Beobachtungen, Band xv., xvi., enthaltend Beobachtungen der Jahre 1892 und 1893, 4to. *Halle a. S.*, 1894 — Royal Hungarian Central Meteorological Institute.

O-Gyalla, Meteorologisch-Magnetische Central-Observatorium, Beobachtungen, 1894, Nos. 5–1895, 4, 4to. *Buda-Pest*, 1894–95 — ———

Open Court, The, Nos. 354–402, 4to. *Chicago*, 1894–95 — The Editor.

Oxford, Radcliffe Observatory, Catalogue of 6,424 stars for the epoch 1890, formed from observations made during the years 1880–93, under the superintendence of E. J. Stone, 4to. *Oxford*, 1894 — The Radcliffe Trustees.

Paris, Académie des Sciences, Comptes rendus hebdomadaires des séances, tome cxviii. 23–cxx. 22, 4to. *Paris*, 1894–95 — The Academy.

Paris, Bureau des Longitudes, Annuaire pour l'an 1895, 16mo. *Paris*, 1894 — Bureau des Longitudes.

—— Éphémérides des Étoiles de culmination lunaire et de longitude pour 1894, par M. Lœwy, 4to. *Paris*, 1893 — ———

Paris, Comité International Permanent pour l'exécution photographique de la carte du ciel, Bulletin, tome ii., fasc. 2, 4to. *Paris*, 1895 — Academy of Sciences.

Paris, Dépôt Général de la Marine, Annales Hydrographiques, série II., 1894, i., ii., 8vo. *Paris*, 1894 — Dépôt de la Marine.

Paris, École Polytechnique, Journal, Cahier lxiv., 4to. *Paris*, 1894 — The School.

Paris, Observatoire, Annales, Observations 1886–87, publiées sous la direction de F. Tisserand, 4to. *Paris*, 1894 — The Observatory.

—— Rapport Annuel, pour l'année 1893, par F. Tisserand, 4to. *Paris*, 1894 — ———

Paris, Société Astronomique de France, Bulletin, et revue mensuelle d'Astronomie, de météorologie et de physique du globe, 1895, 1–6, 8vo. *Paris*, 1895 — The Society.

Paris, Société Mathématique de France, Bulletin, tome xxii. 5–xxiii. 3, 8vo. *Paris*, 1894–95 — ———

The Society. Paris, Société Philomathique, Bulletin, série VIII., tome vi. 2–4, 8vo. *Paris*, 1894–95

The Hydrographer Penang, Longitude of, determined by means of telegraphic signals exchanged with Singapore, 1893, by Commander A. M. Field, Lieutenant W. H. D. Margesson, and A. Sutherland, fol. *London*, 1894

The Author. Perigal, H., Phases of Perigal's retrogressive Kinematic parabola, 16mo. *London*, 1894

The Society. Philadelphia, American Philosophical Society, Proceedings, Nos. 143–146, 8vo. *Philadelphia*, 1894

The Institute. Philadelphia, Franklin Institute, Journal, Nos. 822–834, 8vo. *Philadelphia*, 1894–95

The Society. Physical Society of London, Proceedings, xii. 4–xiii. 7, 8vo. *London*, 1894–95

The Author. Pickering, W. H., Schiaparelli's latest views regarding *Mars*, 8vo.

——— —— Recent Observations of the satellites of *Jupiter*, 8vo. *Northfield, Minn.*, 1894

The Author. Plassmann, J., Beobachtungen veränderlicher Sterne, vierter Theil, 8vo. *Warendorf*, 1895

The Observatory. Potsdam, Astrophysikalisches Observatorium, Publicationen, herausgegeben von H. C. Vogel, Band vii., Theil II. ; Band x. [Scheiner, Spectra der helleren Sterne ; Spörer, Beobachtungen von Sonnenflecken, 1893–95], 4to. *Potsdam*, 1895

The Institute. Potsdam, Königlich Preussische Geodätisches Institut, Jahresbericht des Direktors, 1893–94, 8vo. *Berlin*, 1894

——— —— Veröffentlichungen ; Polhöhenbestimmungen im Harzgebiet, 1887–91, 4to. *Berlin*, 1894

——— —— Feier des hundertjährigen Geburtstages des verewigten General lieutenants Dr. J. J. Baeyer, 4to. *Berlin*, 1894

The Observatory. Prag, K. K. Sternwarte, Magnetische und Meteorologische Beobachtungen im Jahre 1893, Jahrgang 54, 4to. *Prag*, 1894

The Author. Prince, C. L., Observations on the climate of Uckfield, constituting a meteorological record for the district from 1843–1870, 8vo. *London*, 1871

Pritchett, Henry S., Ueber die Verfinsterungen der Saturntrabanten. Inaugural Dissertation, 4to. *München*, 1895 — The Author.

Puebla, Colegio Católico, Observaciones Meteorológicas, año de 1879, fol. *Puebla* — The College.

—— Resumen de las observaciones meteorológicas practicadas durante el año de 1889, 8vo. *Puebla*, 1890 — ——

Queensland Branch of the Royal Geographical Society of Australasia, Proceedings, 9th Session, 1893-94, vol. ix., 8vo. *Brisbane*, 1894 — The Society.

Rajna, M., Sull' excursione diurna della declinazione magnetica a Milano, in relazione col periodo delle macchie solari, 8vo. *Milano*, 1895 — The Author.

Riefler, S., Die Präcisions-Uhren mit volkommen freien Echappement und neuen Quecksilber-Compensationspendel, 4to. *München*, 1894 — ——

Rio de Janeiro, Observatorio, Annuario para o anno de 1894, 8vo. *Rio de Janeiro*, 1893 — The Observatory.

Roberts, Isaac, A selection of photographs of stars, star clusters, and nebulæ, together with information concerning the instruments and the methods employed in the pursuit of celestial photography, 4to. *London*, 1894 — The Author.

Robertson, A., Sectionum Conicarum libri septem ; accedit tractatus de Sectionibus Conicis et de scriptoribus qui earum doctrinam tradiderunt (with MS. notes and additions by Francis Baily), 4to. *Oxonii*, 1792 — E. B. Knobel.

Rome, Accademia Pontificia de' Nuovi Lincei, Atti, anno xlvi., 4to. *Roma*, 1894 — The Academy.

Rome, Reale Accademia dei Lincei, Atti, anni 291-292, Serie V., Rendiconti, vol. iii., semestre i., fasc. 9-vol. iv., semestre i., fasc. 10, 4to. *Roma*, 1894-95 — ——

—— Catalogo delle ascensioni rette medie pel 1890·0, di 2,438 Stelle da A. di Legge e F. Giacomelli, 4to. *Roma*, 1894 — ——

Rome, Società degli Spettroscopisti Italiani, Memorie, vol. xxiii. 5-xxiv. 5, 4to. *Roma*, 1894 — The Society.

Rome, Specola Vaticana, Pubblicazioni, vol. iv., 4to. *Roma*, 1894 — The Observatory.

The Office. Rome, Ufficio centrale meteorologico e geodinamico Italiano, Annali, vol. xii. 1, 2; vol. xiv. 1; vol. xv. 1, 4to. *Roma*, 1893–95

The Society. Royal Dublin Society, Scientific Proceedings, new series, vol. viii., parts 1–2, 8vo. *Dublin*, 1894

——— —— Scientific Transactions, series II., vol. v., parts 1–4, 4to. *Dublin*, 1893

——— Royal Geographical Society, The Geographical Journal, vol. iv. 5–v. 6, 8vo. *London*, 1894–95

The Institution. Royal Institution of Great Britain, Proceedings, vol. xiv., part 2, 8vo. *London*, 1895

The Society. Royal Meteorological Society, Quarterly Journal, Nos. 90–94, 8vo. *London*, 1894–95

——— —— The Meteorological Record, Nos. 51–55, 8vo. *London*, 1894–95

——— Royal Photographic Society of Great Britain, Journal and Transactions, new series, vol. xviii. 10–xix. 9, 8vo. *London*, 1894–95

——— Royal Society of London, Proceedings, Nos. 334–345, 8vo. *London*, 1894–95

——— —— Catalogue of Scientific papers, 1174–83, vol. x., 4to. *London*, 1894–95

——— —— Philosophical Transactions (A), for the year 1894, vol. 185, part 1, 4to. *London*, 1895

——— —— List of Fellows, Nov. 30, 1894, 4to. *London*, 1895

——— —— Meteorological Council, Report for the year ending March 1894, 8vo. *London*, 1895

The Institution. Royal United Service Institution, Journal, Nos. 196–207, 8vo. *London*, 1894–95

The Society. Rugby School Natural History Society, Report for the year 1894, 8vo. *Rugby*, 1895

Agent General for New South Wales. Russell, H. C., Observations of the transit of *Venus*, 9 December, 1874, made at stations in New South Wales, 4to. *Sydney*, 1892

The Author. —— The progress of astronomical photography, 8vo. *Sydney*, 1894

The Academy. St. Petersburg, Académie Impériale des Sciences, Bulletin nouvelle série, tome iv., No. 1–série V., tome ii., No. 2, 4to. *St.-Pétersbourg*, 1893–95

San Fernando, Almanaque Náutico para 1896, calculado en el Instituto y Observatorio di Marina, 8vo. *Madrid*, 1894 — The Observatory.

Scheiner, Julius, Untersuchungen über den Lichtwechsel Algols, nach den Mannheimer Beobachtungen von Professor Schönfeld, 1869–75. Inaugural Dissertation, 8vo. *Bonn*, 1882 — Dr. L. Becker.

—— A treatise on Astronomical Spectroscopy, being a translation of Die Spectralanalyse der Gestirne ; translated, revised and enlarged by E. B. Frost, 8vo. *Boston*, 1894 — Prof. E. B. Frost.

Schiötz, O. E., Resultate der im Sommer 1893 in dem nördlichsten Theile Norwegens ausgeführten Pendelbeobachtungen (Norwegische Commission der Europäischen Gradmessung), 8vo. *Kristiania*, 1894 — The Author.

Schur, W., Bestimmung der Parallaxe des Sterns ψ 5 (56) *Aurigæ*, 4to. *Kiel*, 1894 ——

—— Beobachtungen der veränderlichen Sterne δ *Cephei*, η *Aquilæ*, und β *Lyræ*, nach der Argelander'schen Methode der Stufenschätzungen, 4to. *Kiel*, 1895 ——

Science (extract from), On a card catalogue of scientific literature, 4to. — Dr. H. P. Bowditch.

Sciences populaires, Nos. 1–3, 8vo. *Paris*, 1895 — The Editor.

Seeliger, H., Maxwell's und Hirn's Untersuchungen über die Constitution des Saturnringes, 8vo. *München*, 1894 — The Author.

—— Ueber den vierfachen Stern ζ *Cancri*, 8vo. *München*, 1894 ——

Sirius ; Zeitschrift für populäre Astronomie, Band xxvii. 7–xxviii. 6, 8vo. *Leipzig*, 1894–95 — The Editor.

Smith, H. J. S., The collected mathematical papers of, edited by J. W. L. Glaisher, 2 vols., 4to. *Oxford*, 1894 — Delegates of the Clarendon Press.

Società Meteorologica Italiana, Bollettino mensuale, pubblicato per cura dell' Osservatorio Centrale Carlo Alberto in Moncalieri, serie II., vol. iv. 6–12, 4to. *Torino*, 1894–95 — The Society.

Society of Arts, Journal, Nos. 2,168–2,220, 8vo. *London*, 1894–95 ——

Souillart, C., Sur le degré d'approximation que comporte le calcul des latitudes dans la théorie des satellites de *Jupiter* ; importance des termes du troisième degré, 8vo. *Paris*, 1895 — The Author.

The Author. Spitaler, R., Bahnbestimmung des Kometen 1851, III. (Brorsen), 4to. *Vienna*, 1894

——— Stevenson, Robert, Elasticity a mode of motion; being a popular description of a new and important discovery in science, 8vo. *San Francisco*, 1895

The Academy. Stockholm, Konglige Svenska Vetenskaps Akademie, Bihang till Handlingar, Band xix., Afdelning 1–3, 8vo. *Stockholm*, 1894

The Observatory. Stockholm, Observatory, Astronomiska Iakttagelser och Undersökningar, utgivna af H. Gyldén. Bandet v. 4, 4to. *Stockholm*, 1895

——— Stonyhurst College Observatory, Results of meteorological, magnetical, and solar observations, by the Rev. W. Sidgreaves, 1894, 8vo. *Clitheroe*, 1895

The Society. Sydney, Royal Society of New South Wales, Journal and proceedings, vol. xxvii., 1893, 8vo. *Sydney*, 1894

The Observatory. Tacubaya, Observatorio Astronómico Nacional, Boletin, tomo i. 17–21, fol. *México*, 1894–95

——— ——— Anuario para el año de 1895. Año xv., 16mo. *México*, 1894

The Publishers. (Partridge & Co.) Taylor, Lucy, Astronomers and their observations, 8vo. *London*, 1895

The Author. Tebbutt, John, Observations and orbit elements of Comet Gale, 1894, 8vo. *Sydney*, 1894

——— ——— Report of Mr. Tebbutt's Observatory, for the years 1893, 1894, 8vo. *Sydney*, 1894–95

The Observatory. Tiflis, Physikalisches Observatorium, Beobachtungen im Jahre 1892, herausgegeben von J. Mielberg, 4to. *Tiflis*, 1894

The Author. Tischner, A., Le phénomène fondamental du système solaire, 8vo. *Leipzig*, 1895

——— Todd, Sir C., Meteorological work in Australia, a review, 8vo. *Adelaide*, 1894

The Society. Toronto, Astronomical and Physical Society, Transactions for the year 1894, 8vo. *Toronto*, 1895

——— Truro, Royal Institution of Cornwall, Journal, vol. xii., part i., 1894, 8vo. *Truro*, 1895

Turin, R. Accademia delle Scienze, Atti, vol. xxix. 2–xxx. 4, 8vo. *Torino*, 1894–95 — The Academy.

—— Memorie, serie seconda, tomo xliv., 4to. *Torino*, 1894 — ——

United States Coast and Geodetic Survey, Report of the Superintendent for the year ending June 1892, part ii., 8vo. *Washington*, 1894 — The Survey Office.

University College, London, Calendar, session 1894–95, 8vo. *London*, 1894 — The College.

Upsala, Regia Societas Scientiarum, Nova Acta, series III., vol. xvi., 1893, 4to. *Upsaliæ*, 1893 — The Society.

Very, T. W., Hail-storms, 8vo. *Pittsburgh*, 1894 — The Author.

Vienna, Kaiserliche Akademie der Wissenschaften, Denkschriften, mathematisch-naturwissenschaftliche Classe, Band lx., 4to. *Wien*, 1893 — The Academy.

—— Sitzungsberichte, mathematisch-naturwissenschaftliche Classe (Abtheilung II. a), Band cii. 8—ciii. 5, 8vo. *Wien*, 1893–94 — ——

—— —— (Abtheilung II. b.) Band cii. 8—ciii. 3, 8vo. *Wien*, 1893–94 — ——

Vienna, K. K. Gradmessungs-Bureau, Astronomische Arbeiten, ausgeführt unter der Leitung von Th. v. Oppolzer, herausgegeben von E. Weiss und R. Schram, Band v., vi., Längenbestimmungen, 4to. *Wien*, 1893–94 — The Bureau.

Vienna, K. und K. Reichs-Kriegs-Ministerium, Marine-Section; Relative Schwerebestimmungen durch Pendelbeobachtungen ausgeführt in den Jahren, 1892–94, 8vo. *Wien*, 1895 — Austrian Ministry of Marine.

Vienna, Österreichische Gradmessungs-Commission, Verhandlungen; Protokoll über die am 11. und 13. April 1894 abgehaltenen Sitzungen, 8vo. *Wien*, 1894 — The Commission.

Vogel, H. C., Neue Untersuchungen über die Spectra der Planeten, 4to. *Berlin*, 1893 — The Author.

Washburn Observatory of the University of Wisconsin, Publications, vol. vii., part 2. Meteorological observations, 4to. *Madison, Wis.*, 1894 — The Observatory.

Washington, American Ephemeris and Nautical Almanac for the year 1897, 8vo. *Washington*, 1894 — Office of the American Ephemeris.

Office of the American Ephemeris.

Washington, Extract from the Annual Report of the Superintendent for 1894, 8vo. *Washington*, 1894

The Institution.

Washington, Smithsonian Institution, Annual Report of the Board of Regents, 1892–93, 8vo. *Washington*, 1893–94

——— —— Report of S. P. Langley, Secretary, for the year ending June 1894, 8vo. *Washington*, 1895

——— —— Smithsonian Geographical Tables, by R. S. Woodward, 8vo. *Washington*, 1894

——— —— The varieties of the human species; principles and methods of classification, by G. Sergi, 8vo. *Washington*, 1894

——— —— Bibliography of Aceto-Acetic Ester, 8vo. *Washington*, 1894

——— —— Bureau of Ethnology, Tenth, Eleventh, and Twelfth Annual Report (1888–91), by J. W. Powell, 4to. *Washington*, 1893–94.

——— —— —— List of publications, 8vo. *Washington*, 1894

——— —— —— an Ancient Quarry in Indian Territory, 8vo. *Washington*, 1894

——— —— —— J. G. Pollard, The Pamunkey Indians of Virginia, 8vo. *Washington*, 1894

——— —— —— J. C. Pilling, Bibliography of the Wakshan languages, 8vo. *Washington*, 1894

——— —— —— C. Thomas, The Maya year, 8vo. *Washington*, 1894

The Survey.

Washington, United States Geographical and Geological Survey: Contributions to North American Ethnology, vol. ix., 4to. *Washington*, 1893

The Observatory.

Washington, United States Naval Observatory, Observations made during the year 1889, 4to. *Washington*, 1893

——— —— Magnetic Observations made during the year 1892, by S. T. Brown, 4to. *Washington*, 1893

——— —— Meteorological Observations and Results, 1889, 4to. *Washington*, 1893

U. S. Government.

Washington, United States Treasury Department, Bulletin, Nos. 31–33 (Units of Electrical Measures; The constant of Aberration; The direction and intensity of the earth's magnetic force), 8vo. *Washington*, 1894–95

Webb, T. W., Celestial objects for common telescopes, 5th edition, revised and greatly enlarged, by the Rev. T. E. Espin, vol. ii., 8vo. *London*, 1894 — Messrs. Longman & Co.

Wilde, H., On the multiple proportions of the atomic weights of elementary substances in relation to the unit of hydrogen, 8vo. *Manchester*, 1895 — The Author.

—— On the evidence afforded by Bode's Law of a permanent contraction of the Radii Vectores of the planetary orbits, 8vo. *Manchester*, 1895 — ——

Wilson, W. E., and P. L. Gray, Experimental investigations on the effective temperature of the Sun, made at Daramona, Streete, co. Westmeath, 4to. *London*, 1894 — The Authors.

Winlock, W. C., An account of the progress of astronomy in the years 1889–92 (from the Smithsonian Report), 8vo. *Washington*, 1891–93 — The Institution.

Wolfer, A., Nekrolog von Rudolf Wolf, 8vo. *Leipzig*, 1894 — The Author.

Wolsingham Observatory, Report for the year 1894. — Rev. T. E. Espin.

—— Circular, Nos. 39–41. *Darlington*, 1894 — ——

Yale University, Astronomical Observatory, Report for the year 1893–94, 8vo. *New Haven*, 1894 — The Observatory.

Zenger, C. V., L'Électricité considérée comme un mouvement tourbillonnaire, 4to. *Paris*, 1894 — The Author.

Zürich, Naturforschende Gesellschaft, Vierteljahrsschrift, Band xxxix. 2–xl. 1, 8vo. *Zürich*, 1894–95 — The Society.

Zürich, Schweizerisch-meteorologisches Central-Anstalt, Annalen, 1892, Jahrgang 29, 4to. *Zürich*, 1894 — The Institute.

MSS., Photographs, Drawings, &c., presented to the Society.

Howlett, Rev. F., 3 volumes of drawings of Sun-spots. — Rev. T. Howlett.

Mohammad Al Achsasi Al Mouakket, Calendarium (Arabic, 17th Century MS.), sm. 4to. — E. B. Knobel.

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Avianus, Wilhelm, Directorium Universale ad multifaria matheseos problemata in toto terrarum Orbe, sine discrimine latitudinis locorum, uniformi Methodo, sine Calculo expeditè resolvenda, 4to. *Lipsiæ*, 1665

Bassantinus Scotus, J., Astronomia, fol. *Tornaesii* [*Lugduni*], 1599

Beutel, Tobias, Dissertatio Astronomica de Eclipsibus Solis, præcipue instanti d. II. Julii [Inaugural Dissertation], 4to. *Lipsiæ*, 1684

Blanchinus, Tabulæ Joā. Blanchini Bononiensis, cum plerisqu. additionibus ac nouis tabellis nup. impresse. Per L. Gauricū neapolit. castigate, 4to. *Venetiis*, 1526

Bormeister, S., Christlich vernünfftige Cometen-Betrachtung aus Gelegenheit desz in Monat December 1680 erschienenen grossen Cometen, 4to. *Nürnberg*, 1681

Bulletin Astronomique, 1894–95, 8vo. *Paris*, 1894–95

Ciel et Terre, 1894–95, 8vo. *Bruxelles*, 1894–95

Comet, 1665 April 8 (plate only).

Denores, Jason, Breve Trattato del Mondo et delle sve partis emplici et miste, 8vo. *Venetia*, 1571

—— Tavole del Mondo et della sphera . . . con la spheretta del Cl. M. Triphon Gabriele, 4to. *Padoua*, 1582

Dunn, S., A new and easy method for finding the longitude, 12mo. *London*, 1778

Fontenelle, B., The Life of Sir Isaac Newton, with an account of his writings, 4to. *London*, 1728

Giuffi, Jo. Ant., Tractatus de Eclipsibus, 4to. *Neapoli*, 1623

Gruneberg, Christ., Pandora mathematicarum tabularum, 12mo. *Francofurti ad Viadrum*, 1684

Gütner, Raphael, Fundamentalis, eaqvé Astronomica & Astrologica Doctrina de Conjunctionibus magnis . . . nec non speciatim de Conjunctione magna . . . die XII. Octob. anni currentis MDCLXIII., 4to. *Chemnitii*

Hagen, J. G., Synopsis der höheren Mathematik : Band ii. Geometrie d. algebraischen Gebilde, 4to. *Berlin*, 1894

Hancock, B., The astronomy of comets, 8vo. *London*, 1786

Higgs, G., Photographic Atlas of the normal solar spectrum

Hughes, W., A manual of mathematical geography, comprehending an inquiry into the construction of maps ; with rules for the formation of map-projections, 2nd edition, 8vo. *London*, 1852

Ilmer, G., et A. Krellius, Dissertatio [Inauguralis] de Sole, 4to. *Lipsiæ*, 1669

Knowledge ; an illustrated magazine of science, 1894–95, 4to. *London*, 1894–95

Leadbetter, C., Astronomy ; or the true system of the planets demonstrated, 4to. *London*, 1727

Mahmoud Effendi, Mémoire sur le Calendrier Arabe avant l'Islamisme, 8vo. *Paris*, 1858

Mayer, A., et E. Oloff, Phaenomena Solis a Luna d. I. Martii tecti, et Lunae per Vmbram Tellvris d. XVI. Martii obscvratae [Inaugural Dissertation], 4to. *Vittembergae*, 1737

Monforte, Ant. de, de Syderum intervallis, & magnitudinibus opusculum ; cui accessit ejusdem tractatus de problematum determinatione, 4to. *Neapoli*, 1699

Nature, 1894–95, 4to. *London*, 1894–95

Niceron, J. F., Thaumaturgus opticus . . . pars prima, fol. *Lutetiæ Parisiorum*, 1646

Olbers, W., Sein Leben und seine Werke ; herausgegeben von C. Schilling. Band i., 8vo. *Berlin*, 1894

Parker, G. W., Elements of Astronomy, 8vo. *London*, 1894

Pfautzius, Christoph., et C. Saalbach, Eclipsin Terræ [Inaugural Dissertation], 4to. *Lipsiæ*, 1674

Philosophical Magazine, 1894–95, 8vo. *London*, 1894–95

Popular Astronomy, 1894–95, 8vo. *Northfield, Minn.*, 1894–95

Rasch, J., Cometen Buech. Von dem newen Stern des 73 unnd von den Cometen des 77 unnd 81 Jars, auch von allen anderen Cometen unnd newen Sternerscheinungen, 4to. *München* [cir. 1582]

Scheiner, J. A., A Treatise on astronomical spectroscopy ; being a translation of Die Spectralanalyse der Gestirne, translated, revised, and enlarged by E. B. Frost, 8vo. *Boston*, 1894

S[chwatz], C. G., Mémoire explicatif sur la sphère Caucasienne, et spécialement sur le Zodiaque, 4to. *Paris*, 1813

Wislicenus, W. F., Astronomische Chronologie : ein Hülfsbuch für Historiker, Archäologen und Astronomen 8vo. *Leipzig*, 1895

Woodhouse, R., A treatise on plane and spherical trigonometry, 2nd edition, 8vo. *Cambridge*, 1813

Zeitschrift für Instrumentenkunde, 1894–95, 4to. *Berlin*, 1894–95

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